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Non-Marine Atchafalaya Deltas: Processes and Products of Interdistributary Basin Alluviation, South-Central Louisiana (Fluvial Deposits, Lacustrine).

Robert S. Tye
Louisiana State University and Agricultural & Mechanical College

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NON-MARINE ATCHAFALAYA DELTAS: PROCESSES AND PRODUCTS OF INTERDISTRIBUTARY BASIN ALLUVIATION, SOUTH-CENTRAL LOUISIANA

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NON-MARINE ATCHAFALAYA DELTAS: PROCESSES AND PRODUCTS OF INTERDISTRIBUTARY BASIN ALLUVIATION, SOUTH-CENTRAL LOUISIANA

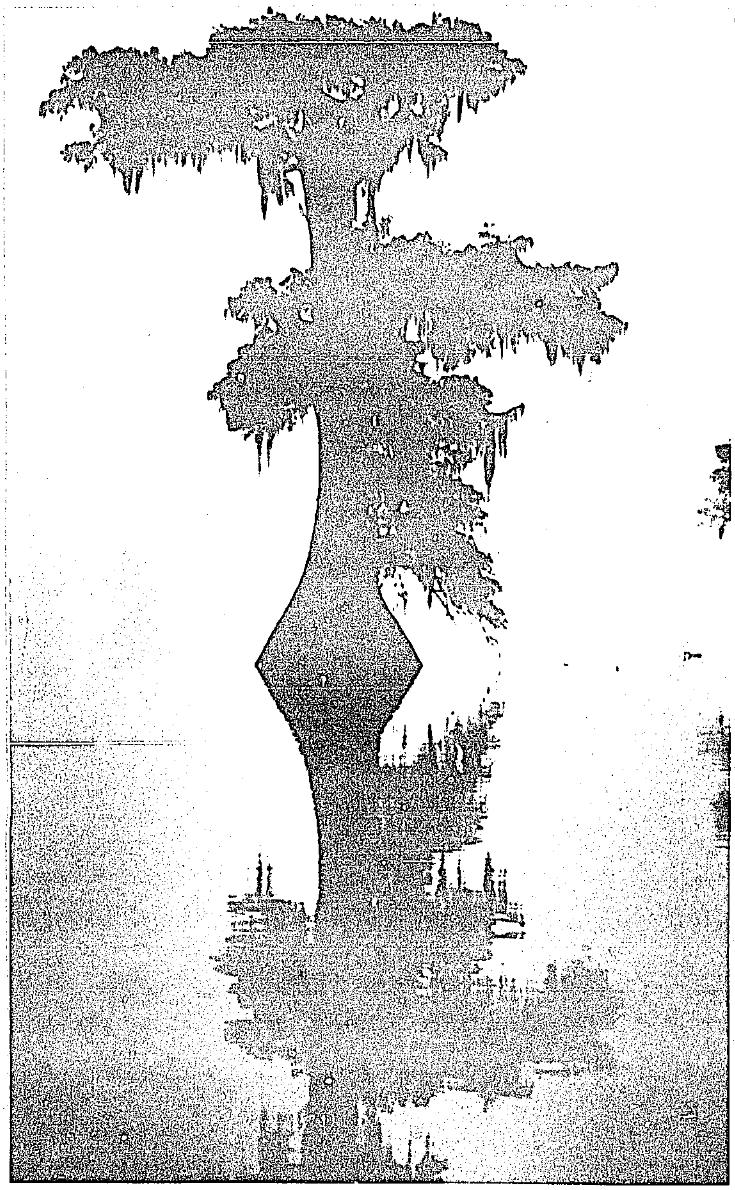
A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Marine Sciences

by
Robert S. Tye
B.S., College of Charleston, 1978
M.S., University of South Carolina, 1981
December, 1986



Bald cypress (Taxodium distichum) on Mestayer Point in Lake Fausse Pointe, Atchafalaya Basin, Louisiana.

This dissertation is dedicated to the memory of my dear friend, John T. Mestayer, whose enthusiasm for geology and friendly spirit will always be with me.

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ABSTRACT

Progradation of lacustrine deltas alluviated the interdistributary lowlands which occupy the transition zone between the alluvial valley and marine delta in the Atchafalaya Basin. Sediment introduced into the basin during the last 700 years by a major Mississippi River distributary has accumulated in the form of thin, regionally extensive deltas. Deltaic sedimentation is cyclic in nature. Rapid subsidence (basin downwarping and sediment compaction), in conjunction with lateral shifts in the site of deposition, creates vertically stacked deltaic wedges separated by backswamp deposits.

One such delta prograded 6.5 km into Lake Fausse Pointe, grew to an area in excess of 29 km^2 in twelve years and is comprised of five depositional environments. A typical vertical sequence consists of coarsening-upward prodelta, delta front, and distributary mouth bar deposits which overlie lacustrine and backswamp sediments. Depositional processes in the lake ranged from suspension-settling of mud and organic matter during periods of low sediment input, to traction deposition of sand during floods. Hyperpycnal flow conditions, set up by sediment-laden water introduced into the freshwater lake, periodically induced underflows which were capable of scouring the lake bottom and depositing coarsening-upward

lobes at their downdip extent. Parallel-laminated prodelta mud and rippled to cross-laminated delta front and distributary mouth bar silty sand are characteristic of rapidly deposited sediment intervals, whereas rooting and burrowing signify periods of relatively low sediment input and lake quiescence.

Delta growth progressed through aggradation and fusion of lobes into large deltaic wedges separated by distributary channels. Within the delta lobes, significant volumes of sand were deposited as dip-elongate linear ridges. Progradation of laterally shifting lobes continued to fill Lake Fausse Pointe until artificial abandonment in the 1930's.

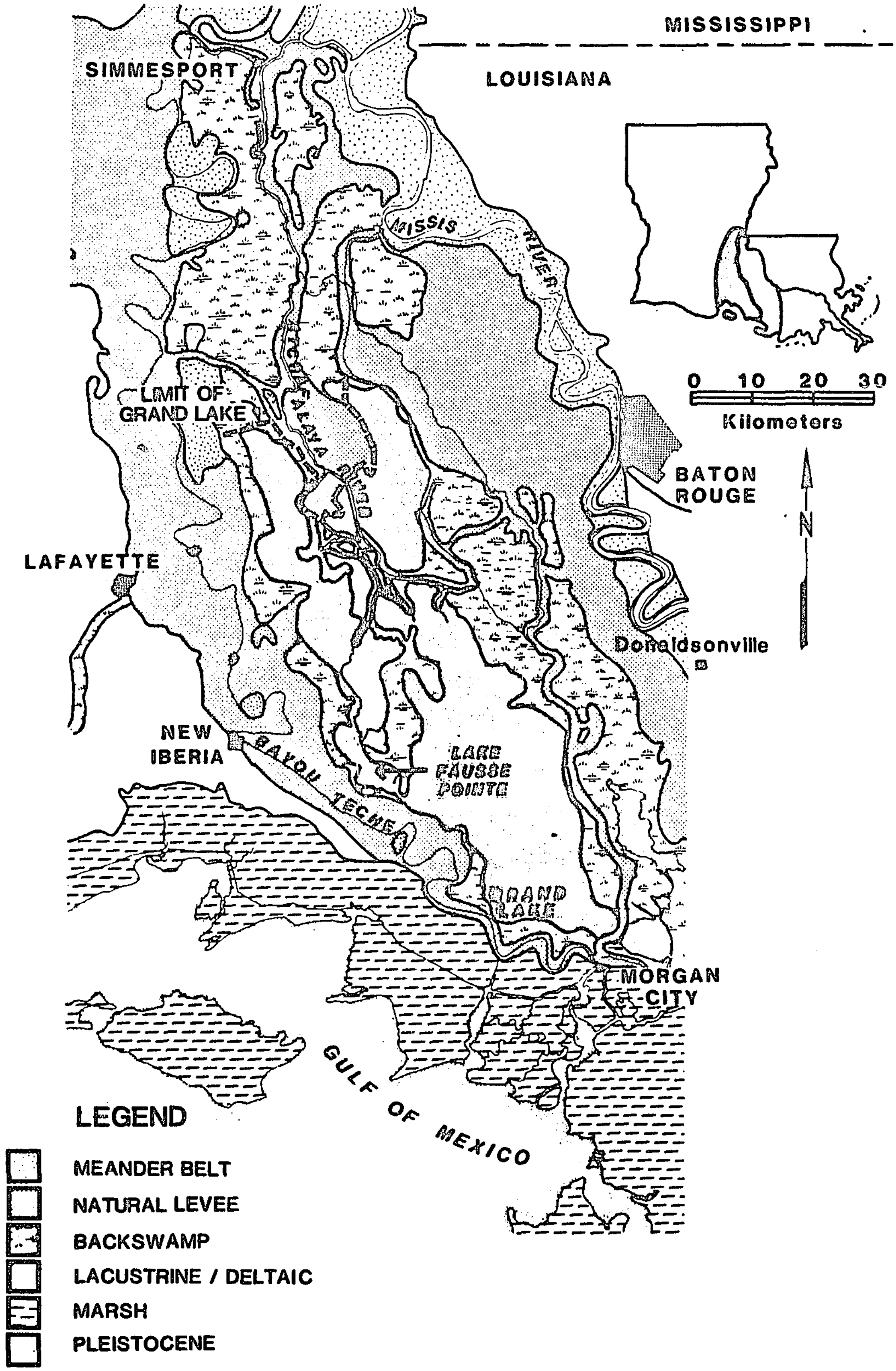
Lake delta formation is a rapidly occurring and continuously repeated process in the Atchafalaya Basin, and, with a significant sediment source, lakes may fill within 100 years. Subsidence accelerates delta abandonment and the development of an overlying backswamp environment. Backswamp transgression creates a new lake to ultimately be filled by another lacustrine delta.

INTRODUCTION

Lacustrine deltas form regionally extensive, relatively coarse-grained deposits within the transitional fluvial/marginal marine zone of the delta plain. Their formation represents a regressive stage in delta plain development, and their deposition precedes the formation of a large marine delta lobe. In seeking a shorter course to the Gulf of Mexico, the Mississippi River has occupied its newest distributary channel, the Atchafalaya River, which in very recent times has introduced large quantities of sediment to a formerly extensively flooded interdistributary basin on the Mississippi delta plain (Fig. 1). Development of the Atchafalaya distributary and aggradation of the delta plain has resulted in the formation of two laterally equivalent deltaic packages: (1) updip freshwater lacustrine deltas; and (2) a marine delta lobe presently filling Atchafalaya Bay (Roberts et al., 1980; Van Heerden and Roberts, 1980; Fig. 2).

The development of the Holocene Mississippi delta plain through progressive delta lobe formation, progradation, and ultimate abandonment has been well-documented (Fisk, 1944; Kolb and Van Lopik, 1958; Coleman and Gagliano, 1964; Frazier, 1967). Frazier (1967) noted that the major delta lobes can be subdivided both chronologically and lithologically to define shifting localized sites of deltaic sedimentation. These individual

Figure 1. Location and geomorphology of the Atchafalaya Basin in south-central Louisiana. The Atchafalaya River has almost completely filled the shallow lakes which once occupied the lower basin. Note the northern limit of Grand Lake, and the location of the study area, Lake Fausse Pointe.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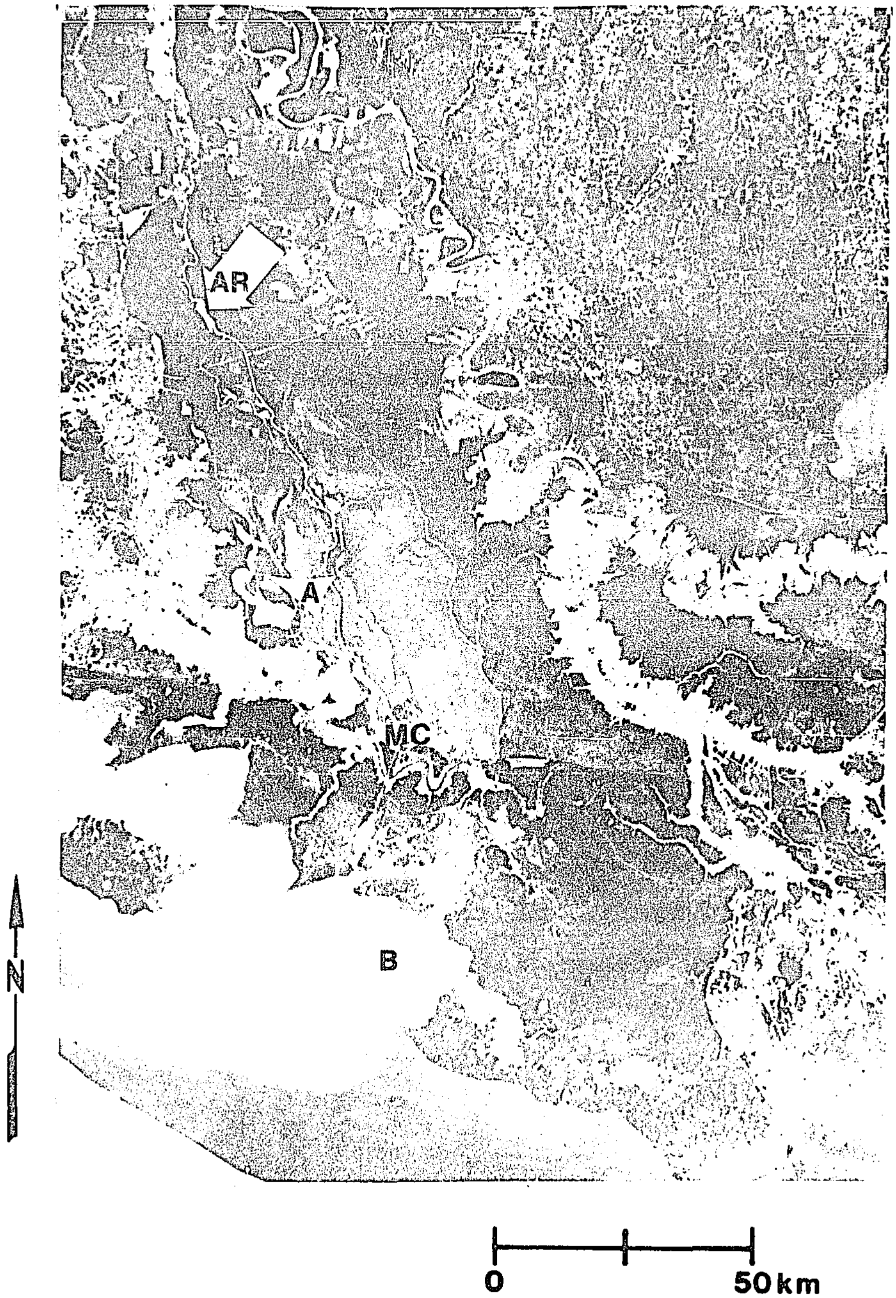


Figure 2. Landsat mosaic of the Atchafalaya Basin, Louisiana. Meander belts of the Mississippi River and Bayou Teche are visible as light-colored ribbons of developed land which surround the basin (dark area) and form the eastern and western basin margins, respectively. Note the chain of lakes north of Morgan City (MC) presently being filled by the Atchafalaya River (AR). The study area is labled (A), and the marine Atchafalaya delta is labled (B).

deltas were fed by a relatively few number of major river courses which essentially followed the shortest route to the Gulf of Mexico to disperse their sediments.

Lateral shifting of the distributary channels in the lower alluvial valley and upper delta plain during the Holocene has isolated large, topographically low areas between the natural levees of the meander belts. One such interdistributary basin is the Atchafalaya Basin, bounded and separated from the rest of the delta plain by the natural levees of the Mississippi River, Bayou LaFourche, and Bayou Teche (Figs. 1 and 2). This interdistributary basin accounts for a significant portion of the fluvial and delta plain sequence in the lowermost part of the alluvial valley. Overall, the Holocene delta plain and lower alluvial valley cover approximately 28,500 km^2 (Smith et al., 1986) and, based on a large numbers of borings, the Holocene sedimentary volume for the Atchafalaya Basin accounts for 6.5×10^5 km^3 of meander belt, lacustrine, and backswamp deposits (Fisk, 1952).

Fisk (1944) divided the sediments deposited within the entrenched Pleistocene Mississippi channel valley into two lithounits: (1) substratum; and (2) topstratum. Figure 3 depicts the arrangement of the Pleistocene and Holocene substratum and topstratum lithounits. Basal substratum sediments are coarse-grained sand and gravel associated with braided stream deposition during periods of low sea-level stand. Overlying the substratum is a complex

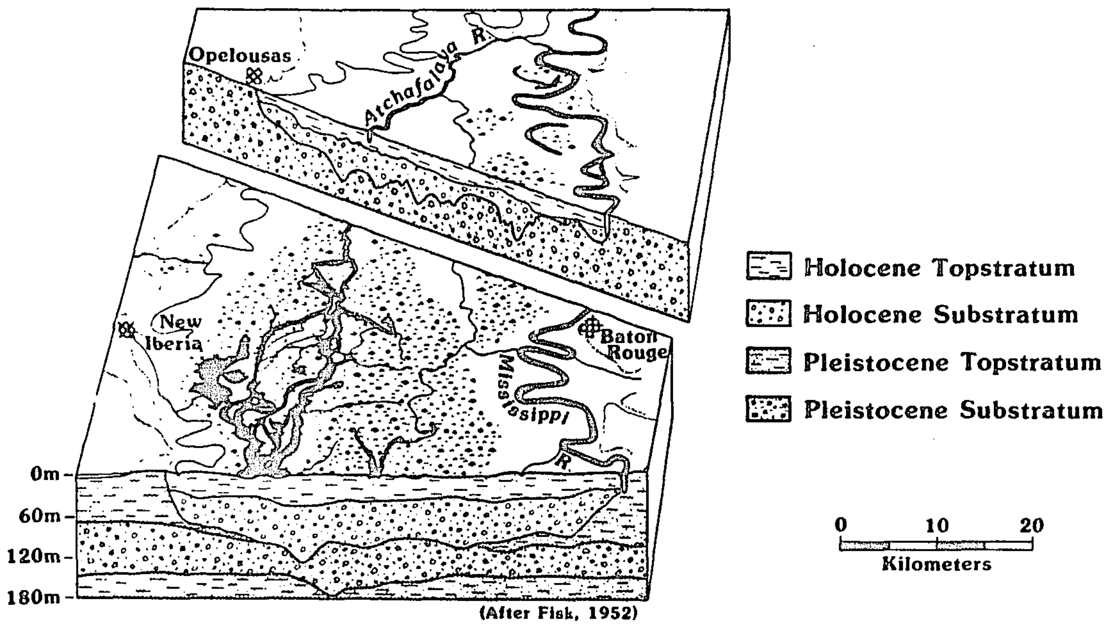


Figure 3. Block diagram from Fisk (1952) illustrating the character of the most recent Pleistocene and Holocene topstratum and substratum deposits in the lower Mississippi alluvial valley.

association of fine-grained sediments deposited in back-swamp, meander belt, lacustrine, lacustrine delta, and marsh environments which comprise the topstratum lithofacies in the alluvial valley. Topstratum deposits reflect aggradation and alluviation of the alluvial valley during periods of rising sea-level. Fisk (1944) also noted that in rapidly subsiding basins, it is the sediments within the lower alluvial valley and delta plain, such as the Atchafalaya, which have the highest preservability.

The purpose of this investigation is to describe the sedimentary characteristics of lacustrine deltas which have formed repeatedly throughout the deposition of the Atchafalaya Basin topstratum. One presently abandoned

Figure 4. High-altitude infra-red photo mosaic of the Lake Fausse Pointe delta. Major physiographic features are: (1) backswamp and cultivated land on the Bayou Teche levees, which form the lake's western margin; (2) the linear artificial levee on the western delta margin which separates Lake Fausse Pointe from the Atchafalaya floodway; and (3) Bird Island Chute (BIC), which is the only passable distributary channel. Note the NW/SE alignment of Fish Island (FI) and Mestayer Point (MP), two backswamp protuberances into the lake. North is to the top of the photograph.

delta in Lake Fausse Pointe was chosen as the study site in which to analyze the sedimentary and geomorphic processes active during progradation of this lacustrine delta (Fig. 4). Sedimentary and stratigraphic information were then used to reconstruct the origin, depositional history, geomorphology, and lithofacies stratigraphy of this deltaic wedge. The resultant information was: (1) applied to better understand the development and facies associations of other complex, multi-lobed lake deltas presently forming in the Atchafalaya Basin; and (2) extrapolated to assess the general similarities and differences among the processes and sedimentary deposits formed in the floodplain of the lower Mississippi alluvial valley.

LOCATION

Basin Geomorphology

Formation and morphology of interdistributary basins and lakes appear to be intimately associated with the regional structure of south-central Louisiana (Fisk, 1944). The northwest/southeast-oriented Five Islands structural axis and the Red River fault zone mark the western and part of the eastern margins of the Mississippi entrenched valley, south of Baton Rouge. To a lesser extent, the Five Islands structural axis has influenced the formation of the Atchafalaya Basin (Fig. 5). The nature of the entrenched Pleistocene drainage was undoubtedly controlled by these structural features and, on a smaller scale, the present position and form of lakes in the lower Atchafalaya Basin closely mimic the Pleistocene structural contours (Fig. 5).

Interdistributary basins evolve through a cyclic progression in which a basin forms and exists over a long time period without receiving a significant amount of detrital sediment. This sediment-poor phase is characterized by expansive backswamp and lacustrine environments in the basin, and is followed by a period of high sediment input and rapid basin alluviation (prograding lake deltas). Delta lobe switching and regional subsidence are the major forces controlling patterns of basin sedimentation and geomorphology. Subsidence enhances basin formation and sequence preservation, and subsidence rates

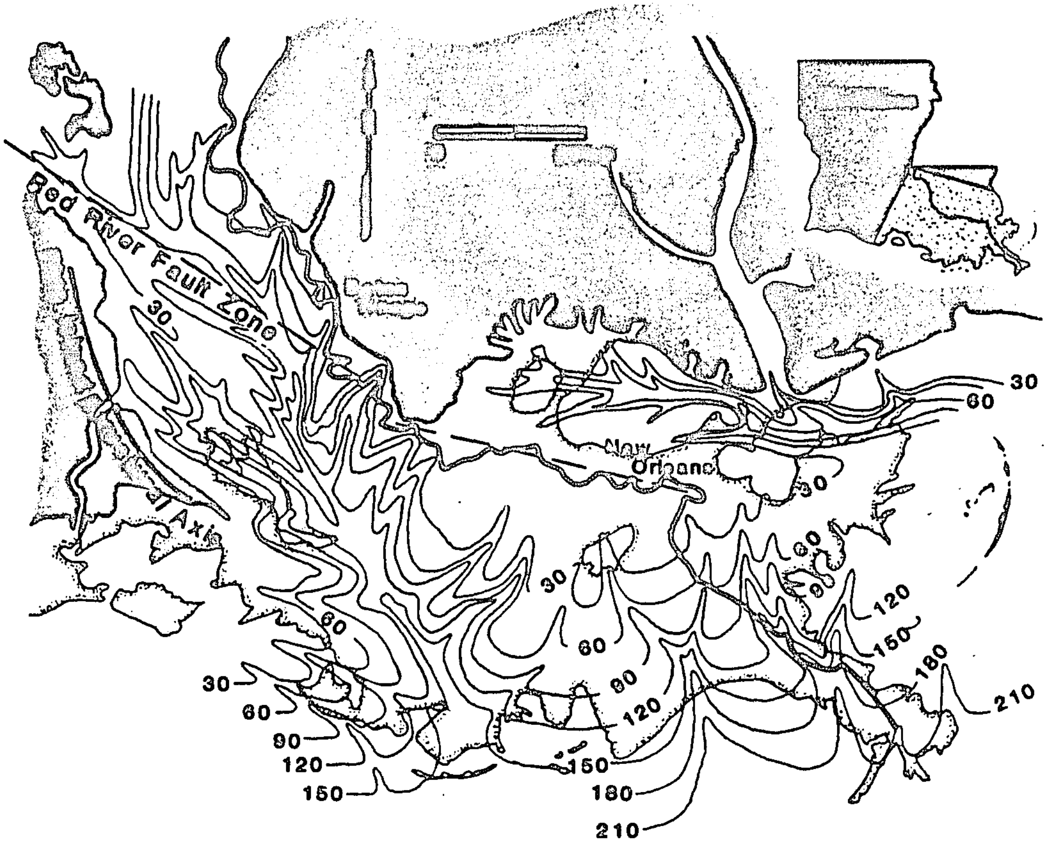


Figure 5. Structure map illustrating the nature of the entrenched Mississippi Pleistocene drainage patterns. Also illustrated are the major structural features which influenced the Pleistocene drainage. Depth values are given in meters. Modified from Fisk (1944).

are in part controlled by the depth to the more stable Pleistocene surface (Roberts, 1986). Subsidence rates for the lower Atchafalaya Basin are rather high and average 1.4 cm/yr (Roberts, 1986).

The distribution of present-day environments in the Atchafalaya Basin (Fig. 1) provides clues to the arrangement and associations of these facies in the subsurface. Primary environments include: (1) meander belt; (2) natural levee; (3) backswamp; (4) lacustrine (5) lacustrine delta; and (6) marsh. The sedimentary characteristics of these environments have been examined in detail by Fisk (1952; 1958), Coleman (1966), Krinitzsky and Smith (1969), and Roberts (1986). Coleman's (1966) treatment of these environments established the guidelines used in this study.

Atchafalaya Basin

A major distributary channel, the Atchafalaya River meanders through the upper Atchafalaya Basin and disperses large volumes of sediment both into the lower Atchafalaya Basin and into the Gulf of Mexico (Figs. 1 and 2). Fisk (1952) attributed the formation of the Atchafalaya distributary to the process of Mississippi meander bend migration and intersection with the Atchafalaya River. Discharge through the Atchafalaya River was insignificant until the 1880's when a log jam on the river was cleared (Fisk, 1952). Later channel improvements (dredging) resulted in such a large increase in discharge (Fig. 6) that it is presently artificially maintained at 30% of the Mississippi discharge (Army Corps Engr., pers. communication).

Russell (1967) stated that, following the Holocene transgression, this basin or estuary extended as far north as Vicksburg, Mississippi. Fisk (1952) has shown,

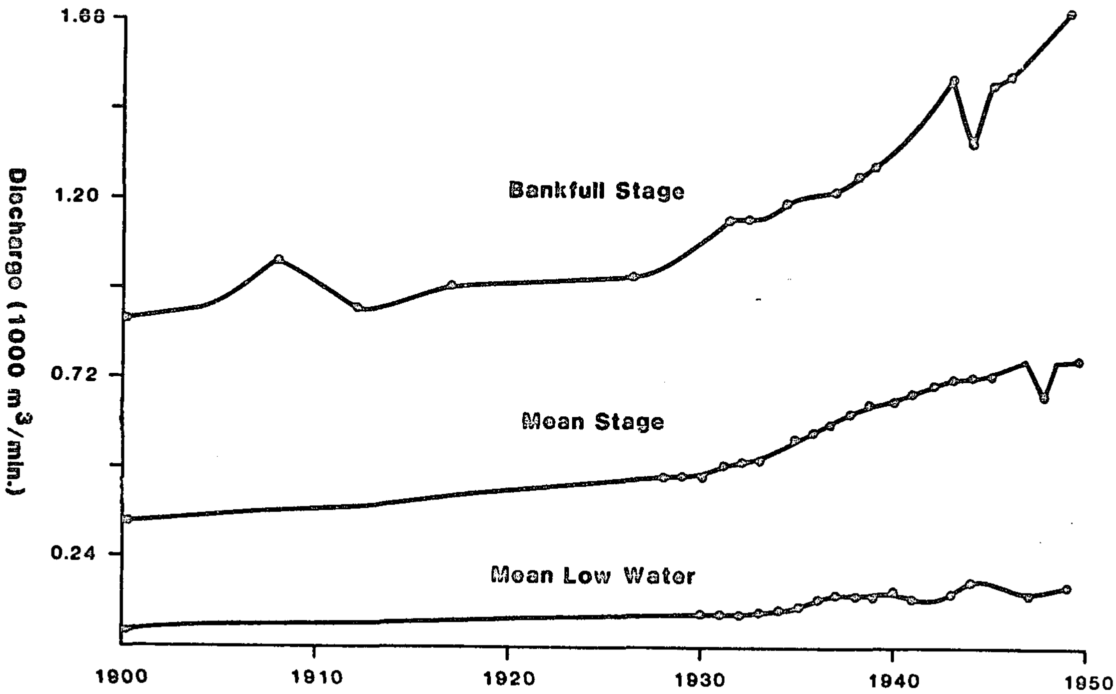


Figure 6. Discharge rates on the Atchafalaya River at Simmesport, Louisiana, from 1900 to 1950. After Fisk (1952).

primarily with archeological data that, as recently as 600 years ago, a large lake extended across the basin from just north of Lafayette down to Morgan City (Fig. 1). The geomorphology of the Atchafalaya Basin at that time consisted of meander belt, backswamp, and natural levee deposits at the head of the basin, and a large lake or series of lakes extending to the south. With formation of a well-defined channel and increased discharge through the Atchafalaya River, meander belt and natural levee sediments were deposited at the expense of the surrounding backswamp. Downslope, clastic sediments from the Atchafalaya River and other basin-drainage channels formed prograding lacustrine deltas which have essentially filled the ancestral lake.

Only a series of lakes north of Morgan City remain partially unfilled (Fig. 2).

Eastward progradation of Bayou Teche and Bayou Black created a barrier to marine incursion in the lower Atchafalaya Basin; thus most of the basin north of Morgan City has experienced little to no saltwater influence. Southward of these bayous, freshwater marsh extends to the Gulf of Mexico (Fig. 1).

Lake Fausse Pointe

Lake Fausse Pointe is one in a series of lakes which occupy the lower Atchafalaya Basin (Fig. 2). Dauterive Lake adjoins it to the north, and prior to artificial levee construction for flood protection, Lake Fausse Pointe had open connections to Grand Lake and Six Mile Lake. Presently, natural levees of Bayou Teche form the western boundary of Lake Fausse Pointe, and Fish Island, a backswamp ridge, separates it from Grand Lake to the southeast (Fig. 4). Sedimentation since 1917 has essentially filled these lakes with deltaic deposits. Fisk (1952) first documented this infilling process through an analysis of the historic evolution of the Grand Lake delta. The deltaic area in Grand Lake now exceeds 100 km^2.

Lake Fausse Pointe is roughly 39 km^2 in area and averages 2.5 m deep, but much of the lake is presently less than 0.5 m deep. Non-marine fauna in the lake sediments imply that saltwater intrusion was not a factor during the history of the lake. Tidal fluctuations are absent in this freshwater basin, but winds out of the southeast are capable of generating choppy waves. Although severed from the floodway basin by levees, local precipitation drains into Lake Fausse Pointe and yearly water levels range from 0.04 to 1.25 m above mean sea level (Army Corps Engineers, Personal Communication). Annual precipitation averages 150 cm in the field area, with July being the wettest month (average of 19.0 cm; Newton, 1972). The Lake Fausse Pointe delta formed between 1920 and 1932 when it prograded 6.5 km into the lake. The delta covers an area just over 29 km^2, and averages 1.92 m thick.

METHODS

Geomorphic data, essential for the determination of the various depositional environments, were derived from topographic maps (recent and historical), soils maps, and high-altitude black-and-white and infra-red photographs. Ground surveys, low-altitude aerial photographs, and fathometer traces established the ground truth for interpretations made from the remote sensing data.

A time-series comparison of maps and photographs (1920-1983) provided the data for reconstruction of the historical evolution of the Lake Fausse Pointe delta, and infra-red aerial photographs portrayed vegetation distribution patterns from which topographic, lithologic, and generalized environmental information could be inferred (Fig. 4). Maps were digitized on an Intergraph system to facilitate reproductions at similar scales and to calculate areas. The existing lake and distributary channel morphology was determined through bathymetric surveys using a Raytheon fathometer. Horizontal scale for the traces was calculated using a partially filled gallon plastic jug and a 10.0 m length of line. A fix mark was placed on the fathometer trace as the milk jug was tossed overboard, and again when the 10.0 m length of line had fully extended. Repeats of this procedure created a reasonably accurate distance scale and accounted for variations in boat velocity.

Subsurface data were acquired using a vibracore system (Lanesky et al., 1979; Smith, 1984) which retrived 90 continuously cored, 7.6 cm diameter samples with a maximum possible penetration depth of 6.0 m. Core penetration was sufficient to recover the entire lacustrine delta and lake bottom sediment sequence. Twelve additional cores were taken using a 0.6 m long cast-iron pipe of 9.0 cm diameter with an iron cap welded on one end. By placing the pipe over a short core tube, and using the handles, the pipe formed a slide hammer which could drive the core tube to the desired depth or to the point of refusal.

Cores were labeled, cut into 1.0 m lengths, and a carbide-tipped saw was used to make four length-wise slices in the aluminium pipe without cutting the sediment. The cores were then split into approximately 1/3 and 2/3 sections using a fine potter's wire. The smaller section (1/3 core) was set aside for handling during core descriptions and sampling. An electro-osmotic knife (Chmelik, 1967) was used to clean the surface of the remaining core sections. These core sections were then photographed (whole core and close-up) and described for lithology, texture, and sedimentary structures using the method of Boyles et al., (1986; Appendix 1). Sediment texture (sand, silt, and clay percentages) and organic content were estimated visually. Sand-size was determined using the Wentworth (1922) scale.

Selected core samples were X-radiographed, both to enhance the appearance of visible sedimentary structures and to bring out structures unapparent in hand sample. Samples were collected in a 30 x 7.6 x 0.8 cm Plexiglas tray inserted into the sediment core and then removed from the core with the potter's wire. This produced a uniform sample of equal length and thickness. X-radiography procedures followed are outlined in Coleman (1966).

SEDIMENTARY ENVIRONMENTS

The character and occurrence of deltaic sedimentary environments are well-documented for marine depositional settings. Most of the investigations of recent environments have focused on the Mississippi Delta Plain, and are almost too numerous to cite. Several important studies of depositional processes and environments span the last fifty years (Russell, 1936; Fisk, 1944, 1947, 1955, 1958, 1961; Fisk et al., 1954; Scruton, 1960; Coleman and Gagliano, 1964; Frazier, 1967; Gould, 1970; Roberts et al., 1980; and Van Heerden, 1983). A fewer number of investigations have been performed in other deltaic settings (Russell, 1942a; Allen, 1965; Coleman, 1969; Coleman et al., 1970; Morgan, 1970; and Oomkens, 1970, 1974; Maldonado, 1975). Coleman and Wright (1975) attempted to classify different delta types and account for their differences in morphology.

Like marine deltas, lacustrine deltas vary in their morphology and their component depositional environments, but have been studied much less extensively than the former. Glacial fjords, rift basins, coastal lagoons, and alluvial valleys are major non-marine to marginal-marine sites of delta deposition (Axelsson, 1967; Donaldson et al., 1970; Kanes, 1970; McGowen, 1970; Hyne et al., 1979; and Syvitski and Farrow, 1983). Numerous parameters in the watershed and receiving basin affect the resultant delta morphology and stratigraphy (Axelsson, 1967; Coleman and Prior, 1980). Of particular importance when comparisons are made to marine settings, is the fact that lake deltas prograde into enclosed basins which are not influenced by tides or strong waves, and owing to high sediment concentrations, the sediment/water plume is denser than the ambient lake water. Thus, hyperpycnal flow conditions are created. Also, in the case of Lake Fausse Pointe, the Atchafalaya Basin has low relief and the lake is shallow. Fisk (1952), Krinitsky and Smith (1969), Roberts (1986), and Smith et al. (1986) presented a geomorphic overview of the various depositional environments comprising the Atchafalaya Basin. Coleman's (1966) treatment of cored sedimentary sequences provided ecological data on the basin-fill deposits.

Six depositional environments in Lake Fausse Pointe comprise the progradational deltaic package in Lake Fausse Pointe (Fig. 7). A seventh environment, the backswamp, is present at the lake margins and a depressed portion of the backswamp forms the lake basin. These environments are lithologically varied, and structures preserved within the cores reflect the physical, biological, and chemical processes chiefly responsible for their development. Cored sequences represent a spectrum from biologically and chemically dominated deposits (burrowing, rooting, diagenesis), to physically deposited and reworked sediments (suspension and traction deposition). Each environment is fairly distinct in its sedimentary character, occurrence, and distribution, but transitions between environments on

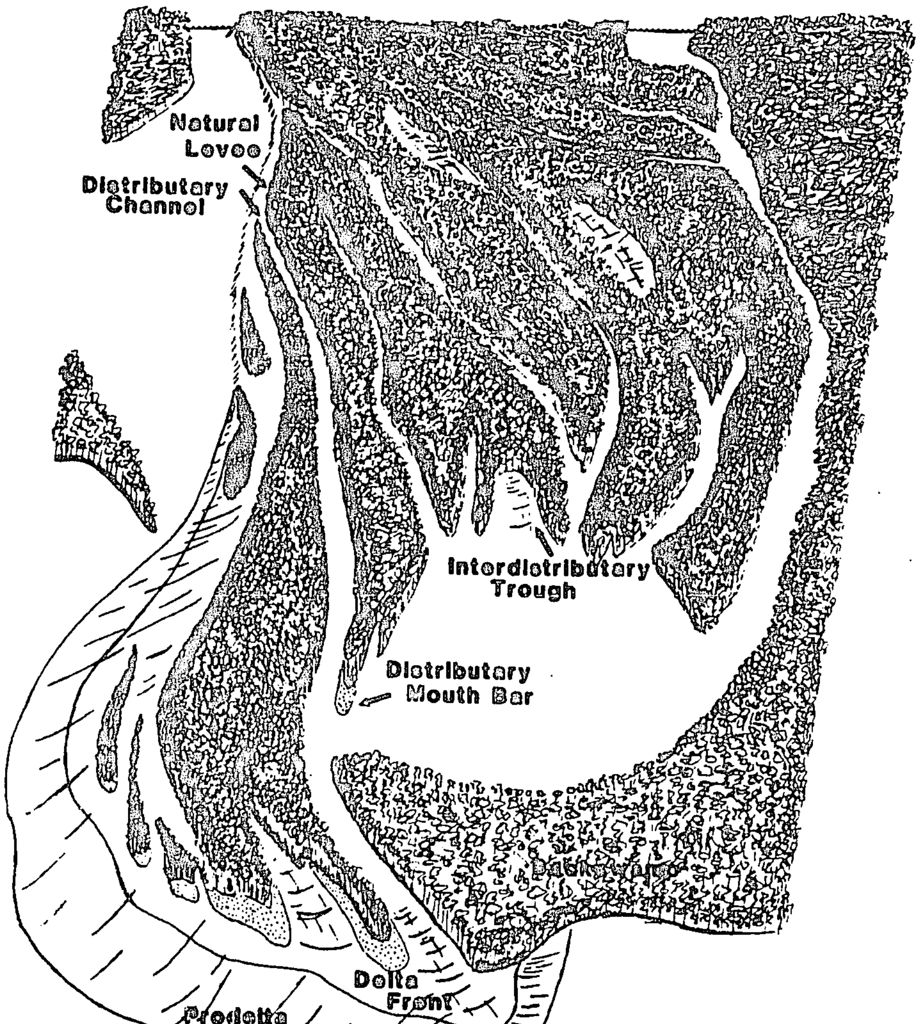


Figure 7. Schematic representation of the depositional environments in a lacustrine delta. No scale intended.

the surface and in the subsurface are typically gradational. Environmental interpretations are based on : (1) sediment composition and texture; (2) sedimentary structures; and (3) lateral associations with other environments.

Backswamp

The backswamp is the most laterally extensive environment in the Atchafalaya Basin (Fisk, 1952; Smith et al., 1986), and forms the upper and lower bounding surfaces for the lake bottom and lacustrine delta sequences. Natural levees of Bayou Teche, the Atchafalaya and Mississippi Rivers, and subordinate basin-drainage channels represent the highest topographic elevations in the basin, and they grade laterally away from the channels into the topographically lower backswamp. Elevations in the backswamp may average just a few decimeters above or below sea level but, due to the occurrence of isolated islands, maximum relief may be on the order of 0.5 m.

Backswamp fringing the Bayou Teche levees forms the western margin of Lake Fausse Pointe, and a large north/south trending backswamp ridge (Fish Island; Figs. 1 and 4) forms the eastern boundary. This backswamp surface has partially subsided, opened, and become flooded to form a series of shallow lakes including Lake Fausse Pointe, Grand Lake, and Six Mile Lake; thus, backswamp is the "basement" for the lacustrine sequences.

Coleman (1966) outlined the environmental conditions and sediment characteristics in well-drained and poorly drained backswamps. The distinction between the two is the periodic occurrence of oxidizing conditions in well-drained swamps versus almost continuous reducing conditions in poorly drained swamps. Organic content is generally higher in poorly drained swamps, because of greater production and/or less degradation by oxidation, and the suite of diagenetic minerals precipitated in the swamp (oxides, phosphates, and/or sulfides) readily attest to the variable and active geochemical conditions that impact the sedimentary record.

Quiet, low-energy depositional processes typify backswamps. Silt- and clay-sized sediment is introduced by overbank flooding from distributary channels and from localized runoff. Fine- to very fine-grained sand is occasionally deposited in the backswamp through channel crevassing as evidenced by stacked, thin coarsening-upward beds (1.0 to 1.3 m thick) of ripple cross-laminated sand with rooted tops. Overall, backswamp sediments are blue-gray to brown in color and contain 50 to 70% clay, with the remainder being silt-sized material. This silty clay is often dewatered and well-compacted. Cypress (Taxodium distichum), tupelo (Nyssa aquatica), sycamore (Plantanus occidentalis), maple (Acer rubrum), willow (Salix nigra) and oak (Quercus palustris and Quercus nigra) trees densely vegetate the backswamp. Their density and distribution vary according to localized drainage conditions. Rooting is the most common biogenic structure and ranges from large cypress root traces to thin, hair-like rootlets (Fig. 8A, B). Burrows are common, usually vertically oriented and silt-filled, but are subordinate to rooting. Thin, poorly preserved laminations accentuated by organic matter are rarely preserved.

Diagenetic products are easily recognized in X-ray radiographs as areas of intense X-ray absorption (white), and occur mostly along burrow and root traces in the form of $FeCO_3$, $CaCO_3$, and/or FeS_2 linings (Coleman, 1966). Pyrite and vivianite, indicative of reducing conditions (Coleman, 1966), may be dispersed throughout the sediments. Calcium carbonate root fillings or nodules are commonly associated with organic material (Fig. 8C). Organic material in the form of roots (fine rootlets to 3.0 cm in diameter), rafted branches, and transported organics (coffee grounds) are common and are dispersed throughout the backswamp sediments. Remains of stumps and logs are present as several cores bottomed in tree remains. *Rangia cuneata*, an oligohaline bivalve, was occasionally observed burrowed into the backswamp surface; however, valves were most commonly preserved in disarticulated form and are concentrated on the backswamp surface as a thin lag. Pulmonate gastropods are present in the backswamp, but are leached in the acidic sediments and rarely preserved

Figure 8. X-ray radiographs of backswamp and lacustrine core samples.

(A) Rooted, dense (light-colored) backswamp clay overlain by rooted organic-rich sediments (dark-colored). Carbonate nodules (a); organic material (b); and large and small root traces (c) are present in the backswamp.

(B) Rooted backswamp overlain by the rippled to highly burrowed lacustrine sediments (arrow denotes approximate contact) Rooting (a) is evident in the backswamp. Transported organic matter (b) and rippled bedded silt (c) occur in the lacustrine deposits. Burrows (d) are common.

(C) Burrowed to bioturbated (>75 % burrows) lacustrine sediments. Diagenetic minerals (a) are present, and some burrows exhibit diagenetic linings (b).
Actual length of core samples is 30 cm.


A
b
c
a
b
B
b
c
d
d
a
C
b
a

(Coleman, 1966).

Lacustrine

A black-to-brown sandy to silty clay lacustrine deposit overlies the backswamp. A sharp contact is common, and intraclasts of backswamp material (several mm in diameter), incorporated in the lacustrine sediments, attest to some local erosion of the backswamp surface. Erosion probably occurred when the swamp was still subaerially exposed, or later with erosion by waves during submergence.

Lacustrine sediments are widely distributed across the lake basin. They represent deposition under essentially low-energy conditions during lake formation and also in a quiescent water body, prior to the fluvial introduction of large volumes of deltaic sediment. The sediments disconformably drape the backswamp, filling lows, and thinning or becoming absent on backswamp highs (shallow areas of the lake). Thickness of the lacustrine deposits averages 10 to 20 cm.

Very fine-grained sand (100 microns) content varies in the lacustrine deposits. It may be absent in cores nearest the lake center, but increases to nearly 50% toward the northern lake margin, possibly indicating the proximity of a source and/or sand enrichment by wave reworking of the marginal sediments. Silt content is less variable, and the lacustrine sediments generally fine upward and may exhibit alternating 10 to 15 cm sandy silt beds overlain by silty clay beds.

Burrowing and rooting have destroyed most of the primary sedimentary structures (Fig. 8B, C). Gastropod, bivalve, and polycheate burrows are obliquely to horizontally oriented and silt- or sand-filled. Often the sediment is bioturbated (>75% of sedimentary structures are burrows), rendering it impossible to define discrete burrow types. Rooting is less common, but root traces and fine rootlets are present. Due to shallow water depths, most of the lake bottom is within the photic zone, and aquatic grasses can be ubiquitous. Therefore, the presence of rooting can only indicate relatively quiet areas with low sedimentation rates. In X-ray radiographs, roots are often diagenetically altered.

Primary sedimentary structures consist primarily of silt and organic laminations. Wispy silt laminae and mm-scale lenticular beds are apparent where burrowing has not homogenized the sediment. Repeated millimeter-thick laminations of normally graded silt to clay indicative of early prodelta sedimentation in the lake, form beds up to 0.5 cm thick. Thicker, individually graded sequences may reach 4 to 8 mm, and commonly show loading deformation on the underlying clay beds.

Leached and abraded Rangia cuneata valves and ostracodes were recovered from the lake bottom. Organic material occurs as pods (macerated organics), thin laminations, leaf, stem, and root debris, and rounded wood chips. Methane gas, derived from the decaying organics, migrates through the sediment, destroys sedimentary structures, and forms gas vugs (1-4 mm in diameter) in the clayey deposits.

Lake Prodelta

Prodelta sediments, the finest-grained deposits within the deltaic complex, form a widespread platform over which coarser-grained deltaic deposits prograded (Fig. 7). The prodelta overlies the lacustrine deposits, ranges in thickness from 0.1 to 1.8 m, and represents the furthest downdip penetration of deltaic sediments into Lake Fausse Pointe. Together with the delta front, it forms a sloping (1:1700) subaqueous surface that extends roughly 0.5 km downdip beyond the subaerial delta. Prodelta deposition occurred 0.75 to 1.0 m below mean lake-water level.

Owing to quiet-water depositional conditions with only rare current or wave action, clay and silty clay sediments predominate in the prodelta. Sand content decreases relative to the lake bottom, most likely because of dilution, but when present, is usually distributed in thin discrete beds. Sediments are mostly deposited by suspension settling of clay flocs and silt grains (Coleman, 1966), and the prodelta clay characteristically exhibits alternating red and gray color banding (1 to 5 cm thick).

A preliminary X-ray diffraction analysis has revealed a mineral suite of smectite, illite, and kaolinite/chlorite which is consistent between the red and gray bands.

In response to the introduction of large volumes of sediment, and decreased burrowing in the prodelta, stratification is well-preserved and ranges from millimeter-scale laminations to beds 2 to 15 cm thick. Coleman (1966) attributed much of the stratification to grain-size variations, mineral and colloidal concentrations, and most importantly, to alternating flocculated and non-flocculated layers. X-ray radiography of selected samples reveals these characteristics (Fig. 9), but primary stratification resulting from grain-size variations and organic matter concentrations is usually visible on the slabbed core surface. The prodelta is burrowed, occasionally rooted, but rarely massive in appearance.

Parallel lamination is by far the most common sedimentary structure. Laminae may be formed by the suspension settling of clay flocs, silt grains, mica flakes, and organic matter. Normally graded silt to clay laminations (1 to 3 mm thick) occur in beds 2 to 15 cm thick (Fig. 9A). Graded beds may have formed by suspension settling following floods, or may have been deposited by the hydraulic sorting of clay flocs and silt grains in turbidity currents (Stow and Bowen, 1978; 1980). Occasional very fine- to fine-grained (88 to 100 microns) sharp-based sand layers, 3 to 4 mm thick, penetrate the prodelta silt and clay. Large floods probably emplaced the sand. Lenticular or ripple cross-laminated sandy silt beds are rare in the lower prodelta. Evenly spaced 2 cm thick silt beds overlain by 5 cm thick clay beds are present; the silt beds increased and thickened upward as the prodelta aggraded into shallower water and was overridden by the delta front.

Soft-sediment deformation in the prodelta resulted in response to loading by the delta front silt and sand. Parallel laminations may be inclined, convoluted, or folded due to slumping. Loaded and deformed laminations, convolute beds (4 to 5 mm thick), flame structures of injected prodelta mud into delta front silt and sand, and faults are almost always present in the upper prodelta. Faults show from 1 to 4 mm to as much as 1.0 cm of offset and bed thickening on the downthrown side. Gas heaving, which deforms beds by pushing them upward (Fig. 9B), is rarely seen in the prodelta.

Burrows are present throughout the prodelta interval, but to a lesser degree than in the lake bottom. Burrowed to bioturbated (>75 % burrows) intervals are 3 to 15 cm thick and alternate with laminated intervals (Fig. 9C). High sediment loads, periodically introduced by floods, deposited the laminated sediments and choked off the benthic fauna. The fauna reestablished itself and churned the sediment during the ensuing quiescent period. Obliquely

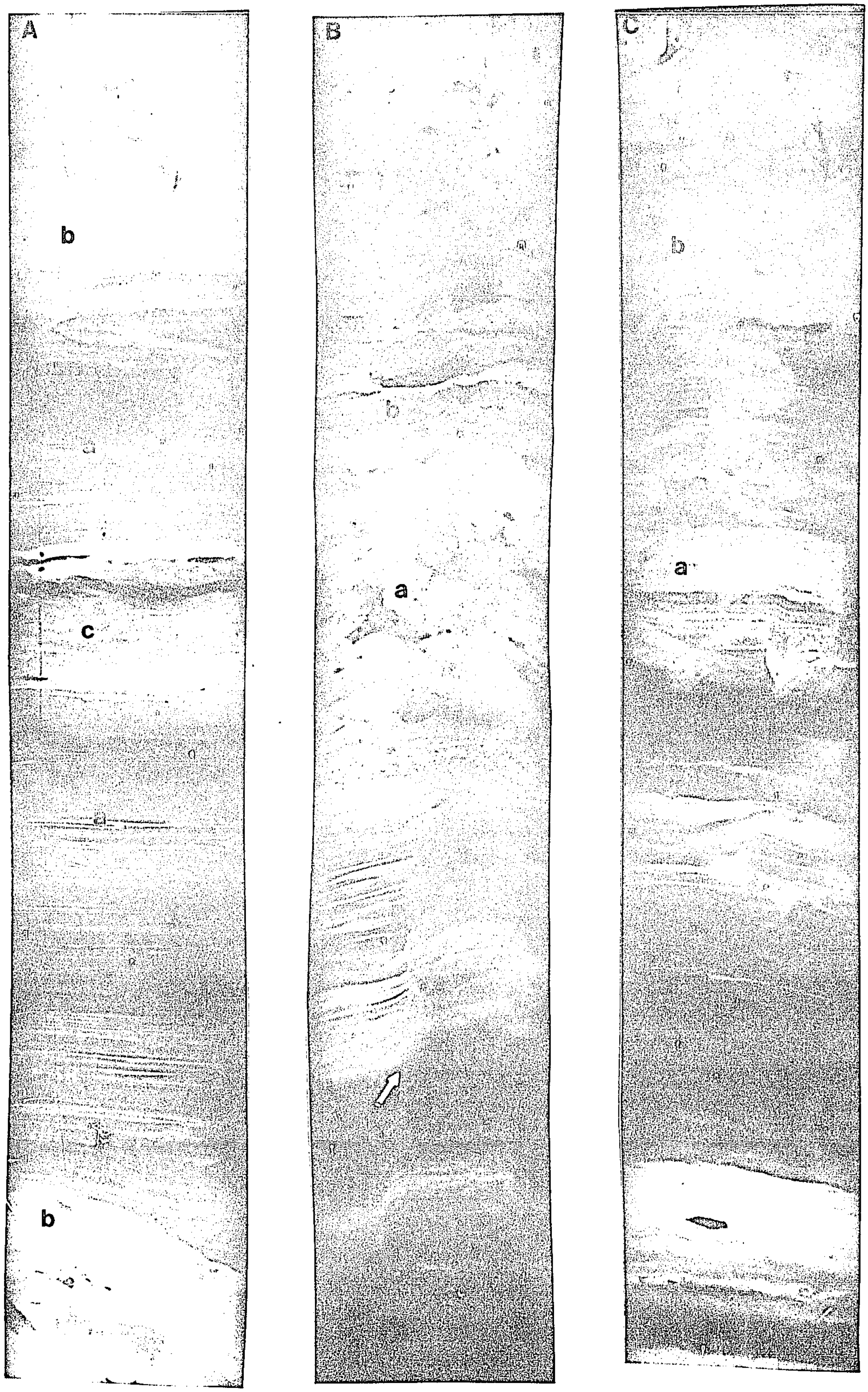
Figure 9. X-ray radiographs of representative lake prodelta core samples.

(A) Finely laminated silt and clay intervals exhibiting normal grading (a) are separated by burrowed (b) and soft-sediment deformed (c) beds.

(B) Deformed silt ripples and clay laminations (arrow) produced by methane migration through the sediment. Burrowed to bioturbated (>75% burrowing; a) and rippled sediments (b) are present.

(C) Alternating laminated (a) and burrowed to bioturbated (>75 % burrows; b) prodelta sediments.

Actual length of core samples is 30 cm.


A
b
c
b
B
a
C
b
a

to vertically oriented sand- and silt-filled burrows with diameters of 0.5 to 1.0 cm are most common. Spreite are readily observed, indicating burrow infilling in response to sedimentation. Large burrows were probably formed by molluscs, although only a few small gastropods and ostracodes have been recovered. Small horizontal and vertical burrows are generally clay-filled and attributed to polycheate worms.

Mudcracks and thin rooted zones occur at the top of the prodelta, particularly in the proximal portion of the delta; thus also indicating periods of low energy and low sediment input. Rooted beds formed as aquatic vegetation colonized prodelta deposits abandoned due to delta lobe switching or low sediment input. Mudcracks were only observed at the prodelta/ delta front contact where the cracks are filled with coarser-grained sediment. Lake-water level periodically dropped to expose and desiccate portions of the prodelta surface prior to delta front progradation.

Lake Delta Front

The delta front is a transitional environment between the underlying prodelta and the overlying distributary mouth bar, and its texture, stratification, and sedimentary structures record important changes in the overall lake delta depositional setting. With the downdip advancement of coarser-grained fluvial sediments, the delta front was deposited over the prodelta and formed a coarsening-upward silty sand deposit that averages 0.5 m in thickness (Fig. 7).

The contact between the prodelta and delta front is almost always gradational. This subtle change results from the variable intensities of flood discharge and sediment load introduced into the lake, and from the lateral shifting of the depositional site. In areas adjacent to the sediment source, the prodelta/delta front contact may be abrupt, and if sedimentation rates are sufficient, the delta front will aggrade and prograde without interfingering significantly with the prodelta.

Initiation of delta front deposition is noted by an upward increase in silt and sand content, and a change in bedding character from laminations largely produced by suspension deposition in the prodelta to ripples indicative of traction deposition in the delta front. Sediment discharged from the distributary channels forms the delta front; thus its thickness and distribution are variable and are controlled by sediment load, river mouth processes, winds, and lake circulation.

Thin-bedded (5 to 15 cm), buff to red-brown, silty and micaceous very fine- to fine-grained (62 to 177 microns) sand characterizes the delta front. In addition, large floods have deposited a few thin (1 to 2 cm) beds of medium-grained (200 microns) sand. Silt content decreases upward and the delta front generally coarsens and becomes more thickly bedded upward.

Fining-upward sediment packages with thicknesses of 5.0 to 10.0 cm may be separated by silty prodelta-like clay, or they may be repeated and stacked forming a continuous sandy delta-front deposit. Normally graded sand to silt sequences, separated by clay, represent the interfingering of the prodelta and delta front environments, implying episodic coarser-grained sedimentation. A typical sequence consists of 1 to 2 cm of massive-appearing to rippled sand overlain by 0.5 cm of parallel-laminated silty sand, capped by 1.0 to 1.5 cm of rippled sandy silt. Conversely, at the prodelta/delta front contact, a 1.0 cm thick ripple cross-laminated silt bed may overlie the prodelta clay. It coarsens upward into rippled sand and is in turn overlain by the fining-upward sand to silt sequences.

Normally graded sedimentation units probably represent energetic depositional conditions, as turbulence was sufficient to entrain silt grains during deposition of the sand ripples. Silt was deposited later during waning flow. In the reverse-graded units, less vigorous currents initially transported silt into the delta front, and with increasing flow strength, sand ripples were deposited. These sequences may actually mark the beginning and increasing flow strength of a major depositional episode in the delta front.

Small-scale current ripple cross-lamination (2 mm to 1.5 cm bedsets) is the dominant sedimentary structure in the delta front. Current ripples may be associated in climbing sets with erosional stoss slopes (Fig. 10A), indicating rapid sedimentation and a relatively high sediment load. More often, the ripples are low amplitude (1 to 4 mm), and have organic, micaceous, or mud drapes. Small-scale trough cross-lamination, small mud rip-up clasts, and scour-and-fill structures are rare. Low amplitude (0.5 cm) symmetrical ripples are present and were probably formed by wave reworking. Flattened ripples, truncated by wind-generated waves, indicate both fluctuations in the lake water level and in the shallow depths of delta front deposition. Mud and/or organic drapes over ripples (wavy beds), flaser beds, and starved ripples (Fig. 10A) attest to alternating traction- and suspension-settling depositional conditions. Particulate organics and mica flakes are concentrated in the ripple troughs.

A variety of soft-sediment deformation structures are found in the delta front environment. Episodic introduction of large quantities of sediment with high fluid content and the progradation of denser silt and sand over less competent fine-grained sediments, resulted in the formation of convolute beds, flame- and fluid-escape structures, and ripple load casts. Convoluted delta-front beds often overlie the prodelta and were formed by deformation and fluid escape during deposition of liquidized silt and sand (Allen, 1984). Ripples usually truncate the tops of the convolute beds. The less competent nature of the prodelta, caused ripples migrating across the prodelta, to founder and sink forming load casts and deforming the underlying laminations (Fig. 10B). Density instabilities produced load casts and associated flame structures. Less dense prodelta clay was injected into the delta front, and delta front deposits penetrated into the distributary mouth bar in response to differential loading.

Significant quantities of transported organic debris (leaves, sticks, root fibers, rounded wood clasts, 0.5 to 4.0 cm in diameter), are incorporated into the delta front. Fine-grained organic particles (coffee grounds) are usually bedded, micaceous, and drape current ripples.

A marked decrease in burrows is noted in the delta front relative to the prodelta, and burrowing decreases significantly from the lower delta front to the upper delta front. Bioturbated intervals are rare. Individual burrows are usually horizontal to oblique and sand-filled, with a diameter of 0.5 cm. Vertical and oblique small-diameter, mud-filled burrows are common and were probably formed by polycheates. Often these burrows are diagenetically lined. As in the prodelta, mudcracks and thin rooted zones (Fig. 10C) indicate low water levels and exposure, along with shifts in the site of deposition.

Lake Distributary Mouth Bar

Deposition of distributary mouth bars represents the culmination of active delta-building in the lake. The distributary mouth bar is an area of shoaling and rapid deposition associated with a prograding distributary channel (Coleman and Gagliano, 1965; Fig. 7). Sediment deposition by current traction processes dominate in this rapidly aggrading shoal-water environment. During floods, sediment is reworked by unidirectional currents. Subsequent wave reworking occurs during non-flood periods or storms, but is probably not as important as in a marine setting (Coleman et al., 1964; Coleman and Gagliano, 1965).

Excluding the updip, proximal portions of the distributary channels, the coarsest-grained sediment in the lacustrine delta is found in the distributary mouth bar. It almost always sharply overlies delta front sediments, but in some instances may gradationally overlie the delta front or channel deposits (Fig. 10C). Thickness averages 0.5 m, but the distributary mouth bar shows a slight tendency to thicken from 0.4 m in the proximal delta to an average of 0.7 m downdip. Distribution of distributary mouth bar sand is limited along depositional strike, but owing to channel progradation, the sand is well-distributed along dip.

Very fine- to medium-grained (100 to 350 microns), moderately sorted sand, with a tendency toward bimodality,

Figure 10. Lake delta front samples.

(A) Core photograph of silty delta front sand displaying climbing ripples (a), mud drapes (b), flaser beds (c), and lenticular beds (d).

(B) Core photograph of load cast (arrows) formed by deposition of delta front sediments over less competent prodelta mud. Ripple beds in the delta front (a) become progressively less deformed upward.

(C) X-ray radiograph of delta front to distributary mouth bar transition; sand-filled mudcrack (a) overlies finely laminated organic matter and silt (b) at the top of the delta front. The overlying distributary mouth bar gradationally coarsens upward into trough cross-bedded sand (c).

Actual length of core samples is 30 cm.


A
a
a
a
b

comprises the distributary mouth bar. Thickly bedded sand (bedsets up to 35.0 cm) is common, but intervals from 1.0 to 10.0 cm are present. Thin mud beds (1.0 to 5.0 cm), distorted by loading deformation, and poorly developed rooted beds indicate that sand deposition is not a continuous process in the distributary mouth bar. Ripple cross-lamination and small-scale trough cross-beds are the dominant physical sedimentary structure. Current ripples form sets from several millimeters to 1.5 cm that thicken upward and often form climbing sets. Multi-directional trough cross-bed sets, formed by cuspate ripple migration, are 2.0 to 10.0 cm thick and usually display tangential foresets (Fig. 10C). Minor traces of scour-and-fill structures and symmetrical ripples were observed. Symmetrical ripples are most common near the top of the distributary mouth bar; thus only small waves were required to rework the sediments. The presence of symmetrical ripples coincides with a textural coarsening trend in the sand. Mud, mica flakes, and mascerated organic matter drape ripples and cross-beds, highlighting the foresets. Flaser bedding, wavy bedding, mud lenses, and ripped-up mud clasts occur in the finer-grained intervals (Fig. 11A, B).

Rapid deposition of relatively coarse-grained sediment, high fluid and organic matter content, fluctuations in water level, and the association of finer-grained sediment intervals, created ideal conditions for soft-sediment deformation.

The delta front/distributary mouth bar contact is texturally abrupt, and often marked by loading deformation of the delta front. Small load casts are formed by sand deposition on mud beds (Fig. 11C). Sand deposition and compaction around wood clasts (0.2 to 6 cm in diameter) distort bedding. Steeply inclined and distorted beds are evidence of slumping in the upper distributary mouth bar and are most likely caused by excessive pore pressures in the sand following a rapid drop in water level (Fisk, 1947).

Fining-upward packages of medium-grained sand to silty fine-grained sand (25 cm thick) occasionally exhibit deformation in the basal coarser-grained layer. Beds in the basal sand are deformed upward and broken. Sand grains were forcibly emplaced in the finer-grained sediment, creating a massive-appearing transition into upper rippled beds (Fig. 11D). This deformation may be due to fluid escape. As the package was deposited rather rapidly, pore waters were initially trapped in the lower sand layer by the overlying fine-grained sediments. Similar features described by Coleman et al., (1964) were defined as gas-heave structures formed by upward migration of methane gas from decaying organic matter. Because deformation is limited to the medium-grained sand intervals, fluid escape is the most likely deformational process.

Flaser beds, mud laminations, rooting and burrowing structures, and silt content increase in abundance in the

Figure 11. Lake distributary mouth bar samples.

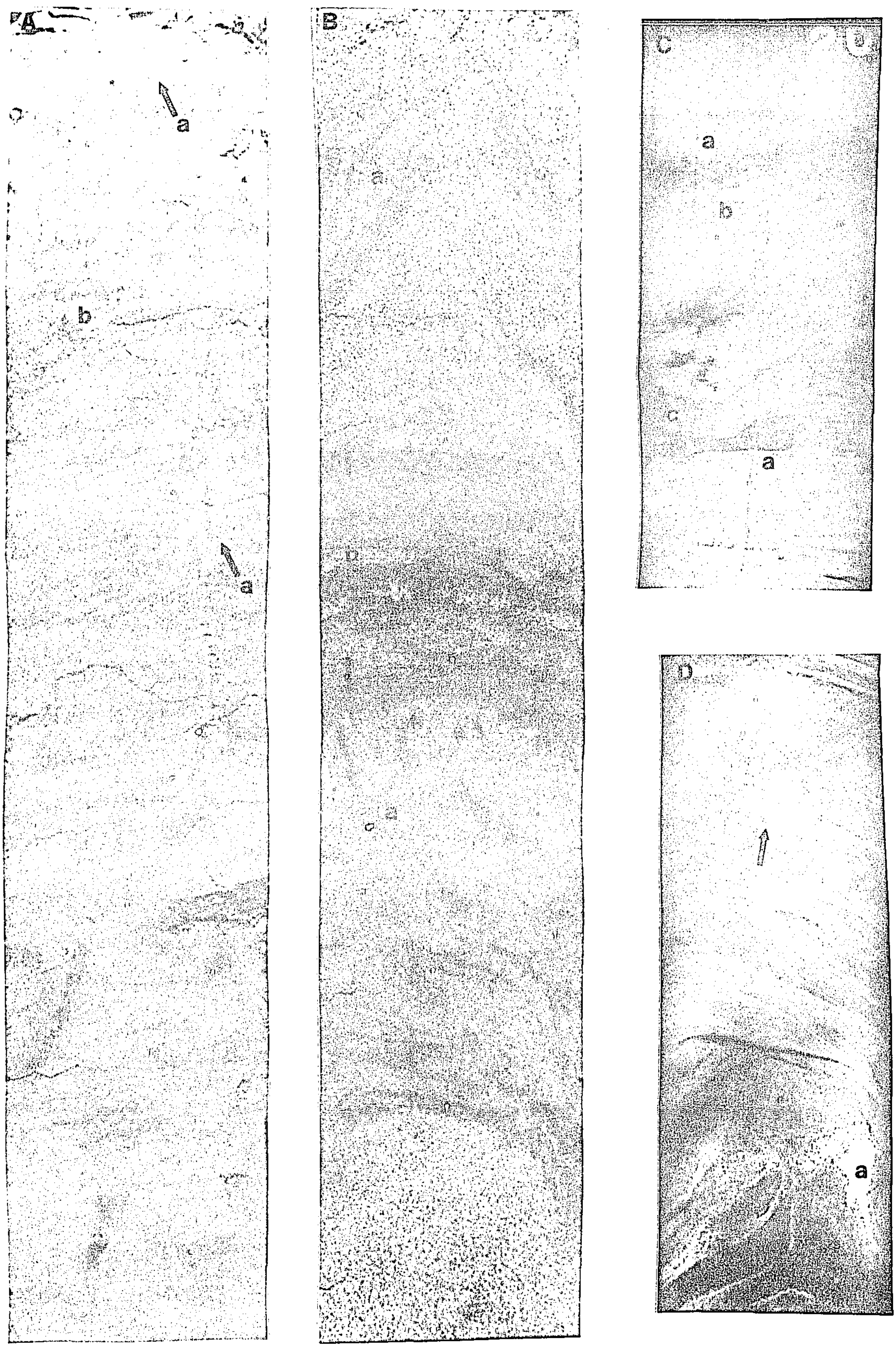
(A) Core photograph of cross-bedded to rippled sand in the upper portion of a distributary mouth bar. Rooting (a) has destroyed some of the physical sedimentary structures. Organic content (b; coffee grounds and clasts) is high in the upper distributary mouth bar.

(B) Distributary mouth bar deposits displaying soft-sediment deformed ripples (a), and lenticular and wavy beds (b).

(C) X-ray radiograph of rooted distributary mouth bar sand (a), a small scour-and-fill structure (b) and ripple load cast (c).

(D) X-ray radiograph of a sand-injection structure (a) formed by fluid expulsion from an underlying permeable sand layer. Note deformation of ripple bedding (arrow).

Actual length of samples A and B is 30 cm. Samples C and D are actually 14.5 and 16.7 cm long, respectively.


A
a
b
a
B
C
a
b
c
a
D
a

upper distributary mouth bar as it is abandoned by channel progradation. The coarsest-grained sediment bypasses the earlier-deposited distributary mouth bar enroute to a new depositional site downdip. This abandonment decreases sedimentation on the older bar, and the bar is subsequently rooted by aquatic vegetation (Fig. 11A). Thin root traces and root hairs destroy ripple bedding. A few horizontally to obliquely oriented burrows are present. Diagenetic minerals ($CaCO_3$, $FeCO_3$, and Fe_2O_3) occur as nodules and linings on roots and burrows (Coleman, 1966; Coleman and Ho, 1968).

Lake Distributary Channel

Approximately nine major distributary channels originated from Grand Bayou at the head of Lake Fausse Pointe. As the channels prograded, they developed an elongate to slightly sinuous morphology and their tendency to spread outward from the delta apex imparts a fan-like morphology to the delta (Figs. 4 and 7). Channels show little to no evidence of lateral migration. They follow a fairly straight course into the lake. Bifurcations are rare, but channels tend to widen and coalesce at their mouths. With continued development, lacustrine deltaic distributary channels, such as those in Grand Lake and Six Mile Lake, have developed an elongate, braided to anastomosing pattern with numerous mid-channel bars or islands, channel bifurcations, and rejoining channels. Anastomosing channel patterns tend to develop in rapidly subsiding areas with low slopes and dense bank vegetation (Smith and Smith, 1980; Smith and Putnam, 1980). Fully developed anastomosing channels are not present in Lake Fausse Pointe because of the floodway protection levee.

Distributary channels have prograded between 5.5 and 6.5 km into Lake Fausse Pointe. Original channel widths varied from 30 to 120 m and most channels widened downdip. All distributaries have narrowed significantly since abandonment of the delta; some channels are barely navigable because of sedimentation. Small channels of variable length and width which branch from major distributaries, were probably ephemeral in nature, and formed through overbank flow (Welder, 1959; Van Heerden, 1983).

Fathometer traces through the only passable channel reveal a flat bottom with occasional irregular reaches. Depth averages 1.5 m with a downdip shallowing trend. A mid-delta channel cross-section exhibits an asymmetric profile with an accretional and erosional bank. Downdip, the channel flattens, and assumes a broad symmetrical U-shaped form.

Channel deposits range from 0.8 to 2.4 m thick and have good continuity along dip, but distribution is very restricted along strike. Bedding may vary from thin to thickly bedded (10 to 60 cm), fine- to medium-grained sand

(125 to 350 microns), to coarsely interbedded sand (10 to 20 cm) and mud beds (10 to 15 cm). Basal channel contacts are texturally abrupt to scoured. Currents transporting and depositing medium-grained sand had sufficient strength to locally erode the backswamp surface as evidenced by angular rip-up clasts. These clasts were not transported, as they can be refitted into their original position (Fig. 12A).

Ripple cross-lamination (0.5 to 2.0 cm sets) and small-scale tangential cross-beds (10 cm sets) are the most common sedimentary structure. Cuspate ripples formed small trough cross-bed sets separated by truncation surfaces (Fig. 12B). The numerous concave-up surfaces in Figure 12B imply constant unidirectional currents. Larger-scale cross-bed sets were deposited by migrating megaripples or straight-crested, low-amplitude sand waves. Often these beds are oversteepened, convoluted, or slumped due to the release of high pore pressures during a drop in the water level or high-flow shear stress (Harms et al., 1963; Coleman, 1969; Allen, 1984). Massive-appearing sand beds are also common. Organic debris (coffee grounds) and mica-rich laminae drape foresets and fill ripple troughs. Mud laminae (0.5 to 1.0 cm) deposited during low-flow conditions may drape sand beds. Flaser bedding, clay rip-up clasts, scour-and-fill structures, and rare symmetrical ripples occur in the channel sand.

A large volume of detrital organic debris is incorporated into the channel deposits. Macerated organic

Figure 12. Lake distributary channel core samples.

(A) Core photograph of ripped-up backswamp intraclasts (a) in medium-grained sandy channel deposits.

(B) X-ray radiograph of centimeter-scale ripple bedsets displaying both planar tangential (a) and trough (b) cross-bedding.

(C) X-ray radiograph of fine-grained sediment forming in an abandoned channel. Note occasional ripples (a) and laminated beds (b), plus the increased organic matter content (dark areas).

Actual length of core samples is 30 cm.


a
a
b
a
c
b
a

material, charcoal, and rounded wood chips (2 to 5 cm in diameter) are bedded with the sand, usually where a large amount of debris is present.

Upon abandonment, aquatic vegetation roots the sand, and fine-grained sediment and organic matter accumulate rapidly to form an abandoned channel clay plug (Fig. 12C). This is a gradual change, and rippled to laminated silt and sand beds introduced by floods occur in the clay plug; their thickness and frequency decrease upward. Natural levees encroach into the abandoned channel, vegetation baffling enhances suspension settling, and organic debris chokes the channel (Fig. 13). Occasional vertical burrows

Figure 13. Abandoned distributary channel. Once abandoned, the channel fills with fine-grained sediment and organic debris. Aquatic vegetation roots on channel bottom, and the vegetation on the natural levees encroach into the channel to completely seal it.

are found in the abandoned channel sediments, but rooting is by far the dominant structure.

Lake Overbank

Periodic flooding of the delta leads to the transportation of sediment outside of and lateral to the distributary channel banks. Overbank deposits in Lake Fausse Pointe occur in two distinct geomorphic regions which comprise the delta surface: natural levees and interdistributary troughs. Channel levees and interdistributary troughs differ significantly in their sedimentary, hydrologic, and topographic character, and therefore support different plant species, making them easy to identify on infra-red photographs (Fig. 4). Russell (1936), Fisk (1944; 1947), Fisk et al. (1954), and Welder (1959) described the processes of development and sedimentary character for levees and interdistributary troughs on the Mississippi delta.

Natural Levees

The topographically highest features on the delta plain (approx. 1.0 m AMWL), natural levees line all of the distributary channels (Fig 7). Maximum levee thickness (1.0 m average; range from 0.6 to 2.0 m) occurs adjacent to the channels, and levees gently slope and thin away from the channels into levee swales or interdistributary troughs.

In the proximal delta, levees have coalesced to form a rather continuous backswamp plain with the characteristics of a well-drained swamp (Coleman, 1966). Levees attain individuality as channels spread downdip and become better separated by interdistributary troughs. Widths of individual levees range from 50 to 200 m; height and width decrease downdip.

Sediments on natural levees are buff to red-brown and range in lithology from very fine- to fine-grained silty sand to a clayey silt. Levees most commonly gradationally overlie the distributary mouth bar, but may, to a lesser extent, overlie channel, delta front, or interdistributary trough sediments. They rarely overlie the prodelta. Because the distributary mouth bar/natural levee contact is gradational over several decimeters in core samples, the base of the natural levee was defined by the upward increase in fine-grained sediment content, and by the change from dominantly physical sedimentary processes in the distributary mouth bar to biogenic processes in the overbank.

Bedding in the levees tends to be thick (> 30 cm) except where thin fining-upward sediment packages are observed. One flood event may deposit a 15 to 25 cm sequence of ripple-bedded sand which grades upward into thinly bedded rippled silt. As natural levees only actively receive sediment during floods, intense rooting and total disruption of primary stratification is characteristic (Fig. 14A). Rapidly deposited sand beds are less severely rooted, and 0.5 to 1.0 cm ripple bedsets are incompletely preserved (Fig. 14B). Flaser beds and mud drapes forming wavy beds are present.

During non-flood conditions, biogenic processes and diagenesis predominate. Organic matter content, mostly in the form of roots and coffee grounds, is relatively high, and increases upward into a thin (15 to 20 cm) backswamp soil. Small, rotated sediment blocks formed by channel bank slumping, rounded clay intraclasts, and vertically oriented burrows are features occasionally observed in cores. Diagenetic products, most commonly iron oxide and calcium carbonate, occur abundantly in association with root and burrow traces (Fig. 14B, C).

Interdistributary Troughs

Topographically depressed and isolated, interdistributary troughs, are almost continuously flooded. These low-energy regions on the delta plain (Fig. 7 and 15) exhibit many of the traits of a poorly drained swamp as described by Coleman (1966). Rapid distributary progradation bypasses and deflects sediment from these areas, therefore, rates of organic accumulation are relatively high, and fine-grained terrigenous clastic sediment is only introduced during flood stage.

Trough development is initiated by channel bifurcation and the development of an anastomosing pattern such that

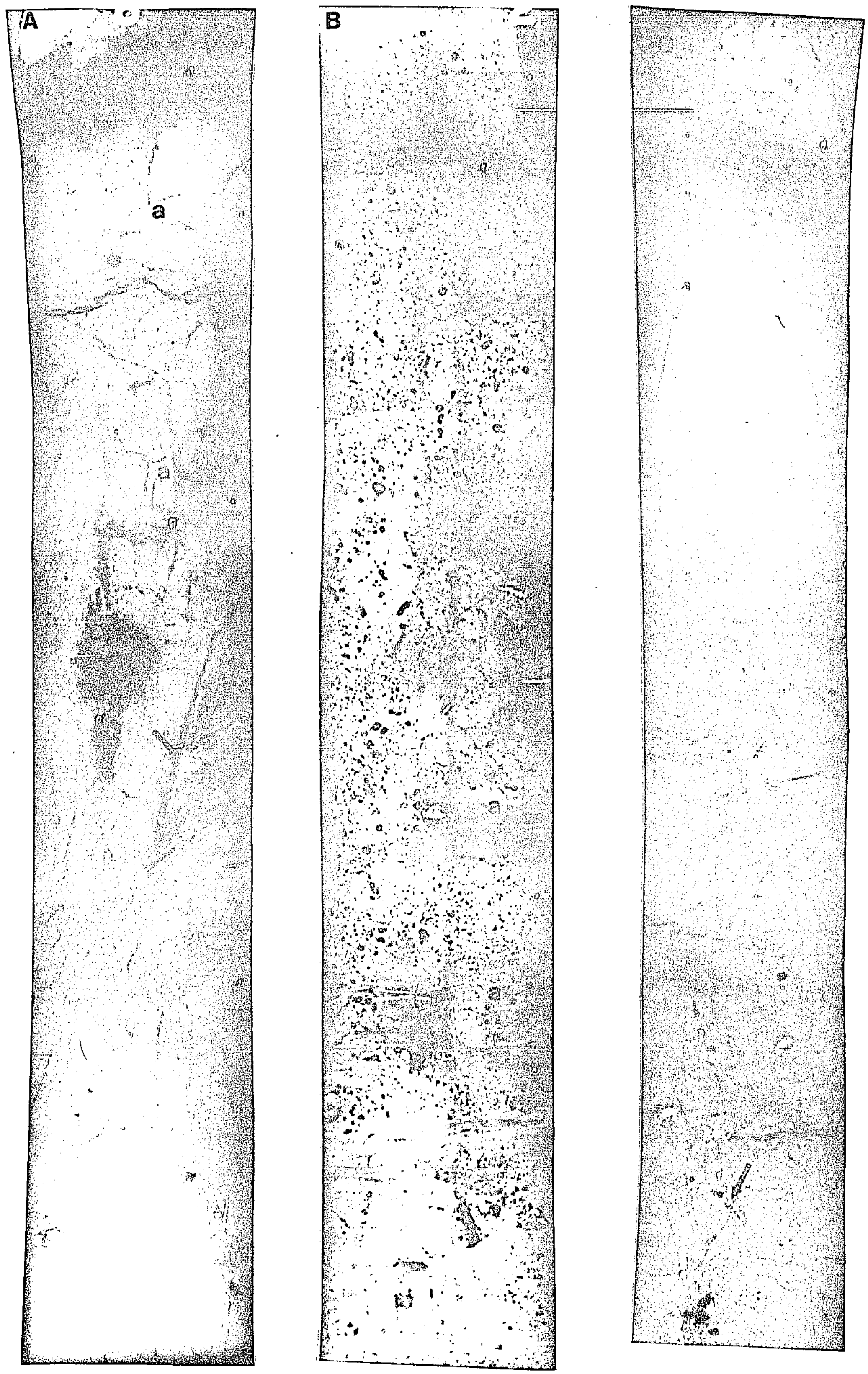
Figure 14. Lake natural levee samples.

(A) X-ray radiograph of rooted (a) to massive-appearing natural levee deposits. Arrow marks poorly preserved ripple bedding.

(B) X-ray radiograph of organic-rich natural levee sediments in which ripple bedding (a) has been largely destroyed by rooting. Light areas (arrows) represent diagenetic mineralization related to the organic matter.

(C) X-ray radiograph of massive-appearing to rooted levee deposits displaying diagenetic linings along root traces (arrow).

Actual core length is 30 cm.


A
a
B

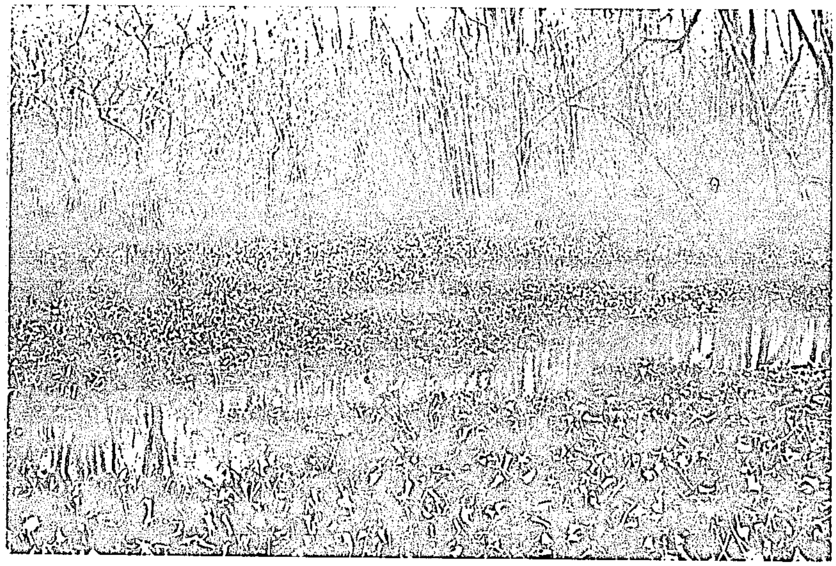


Figure 15. Interdistributary trough present on stratigraphic cross-section B. Water depth is approximately 1.0 m, but dark area on trees represents the level of previous floods. Willow trees and water hyacinths, although dormant during winter, are the most common vegetation types.

the interchannel area receives little to no sediment. Channel morphology controls the geometry of the troughs, and in the Lake Fausse Pointe delta, they grade from small linear or lens-shaped areas in the proximal delta to larger, open-ended triangular features downdip (Fig. 16). The junction of two distributaries encloses a trough to give it the lens-like form. Troughs range in area from several hundred square meters to several square kilometers, and depths average 2.0 m.

Silt and clay mixtures of various percentages, with a very minor amount of very fine-grained sand, comprise the

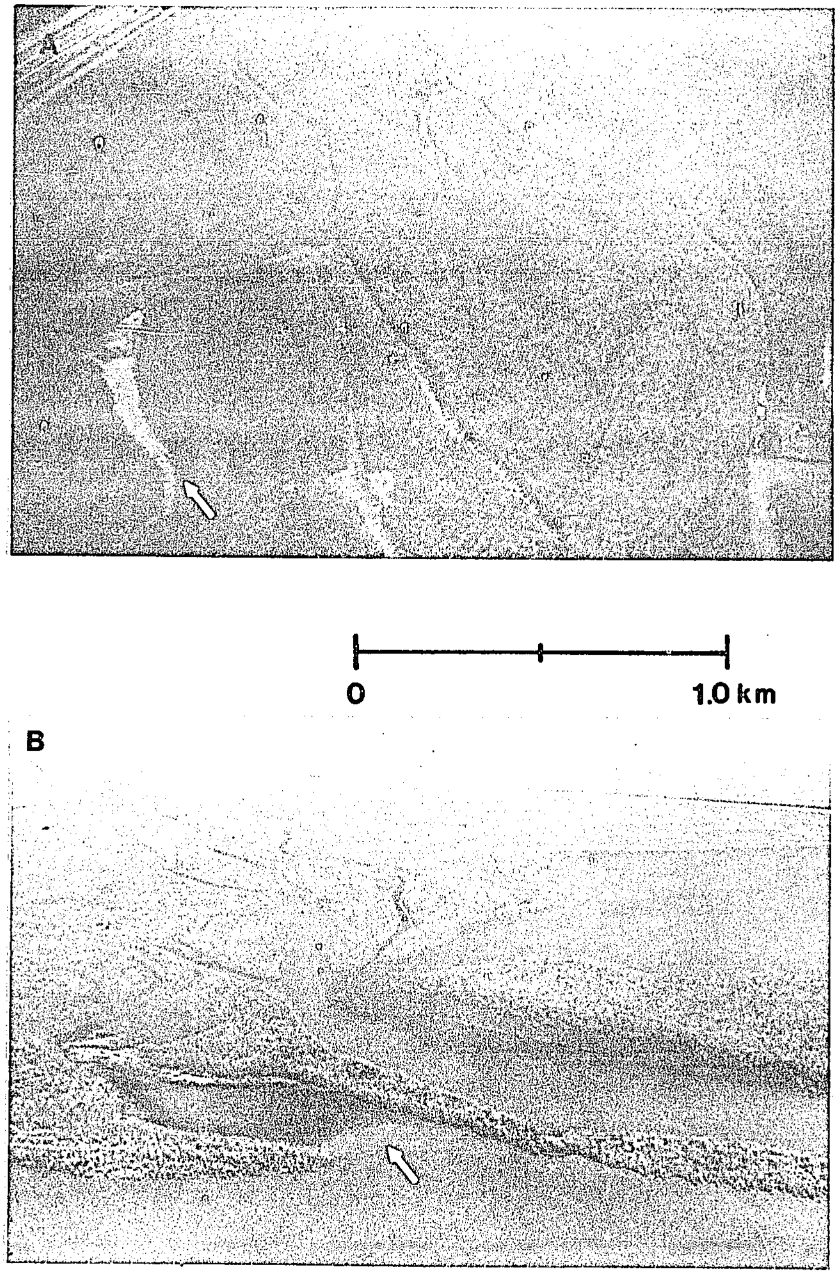


Figure 16. Low-altitude photographs of a lens-shaped interdistributary trough in the proximal delta (A), and an open-ended trough in the delta front area (B). With continued progradation, the trough in photograph B would have closed. Note the elongate sinuous form of the channels which exhibit few bifurcations.

interdistributary trough sediments. Thickness of the interdistributary trough deposits varies. In small troughs, the thickness may be 0.4 to 0.8 m, whereas the thickness ranges from 1.1 to 2.0 m in the larger troughs. Delta front, prodelta, and rarely, distributary mouth bar or backswamp deposits gradationally underlie the troughs.

The presence of rooting is an important criteria in recognizing the interdistributary trough deposits, but the sediment is not as intensely rooted as on the natural levees. Common physical sedimentary structures include finely graded laminations of silt, clay, and organic matter (Fig. 17A, B), ripples, and lenticular beds. Mud beds rarely exhibit desication cracks. Inclined laminae, suggestive of sediment slumps and faults, are present (Fig. 17B, C). Macerated organic matter is dispersed throughout the sediments and also forms laminations. Root and stem fragments, leaves, and seed pods constitute most of the coarser-grained organic debris. Oblique and horizontally oriented burrows are present, and some diagenetic mineralization is apparent along burrows and root traces. Pyrite commonly lines roots and forms framboids in these reduced muds (Coleman, 1966).

Figure 17. X-ray radiographs of interdistributary trough core samples.

(A) Finely graded laminations of silt, clay, and organic debris (a) interbedded with rooted mud (b).

(B) Finely laminated and rippled silt and clay beds exhibiting small slumps (arrows).

(C) Mudcracks in the interdistributary trough (a) implying periodic exposure.

Actual core sample lengths are 30 cm.


A
4
a
b
B
C
a

LAKE DELTA STRATIGRAPHY

Preliminary work on the subsurface character of lacustrine delta deposits in Grand Lake distinguishes two lithologic units which abruptly overlie a blue-grey clay (Fisk, 1952). Delta progradation had formed a coarsening-upward sequence (4.6 m thick) composed of: 1) a basal red silty clay horizon; and 2) an upper brown, sandy to silty clay. These lithounits form a wedge-shaped sediment body in the lake and exhibit good continuity along strike and dip. Fisk (1952) attributed the basal lithounit to Red River sediment deposited by the Atchafalaya River prior to being influenced by the Mississippi River, and proposed that with the joining of the Mississippi and Atchafalaya Rivers, the coarser-grained brown sediments were introduced into the Atchafalaya Basin and deposited over the red clay in Grand Lake.

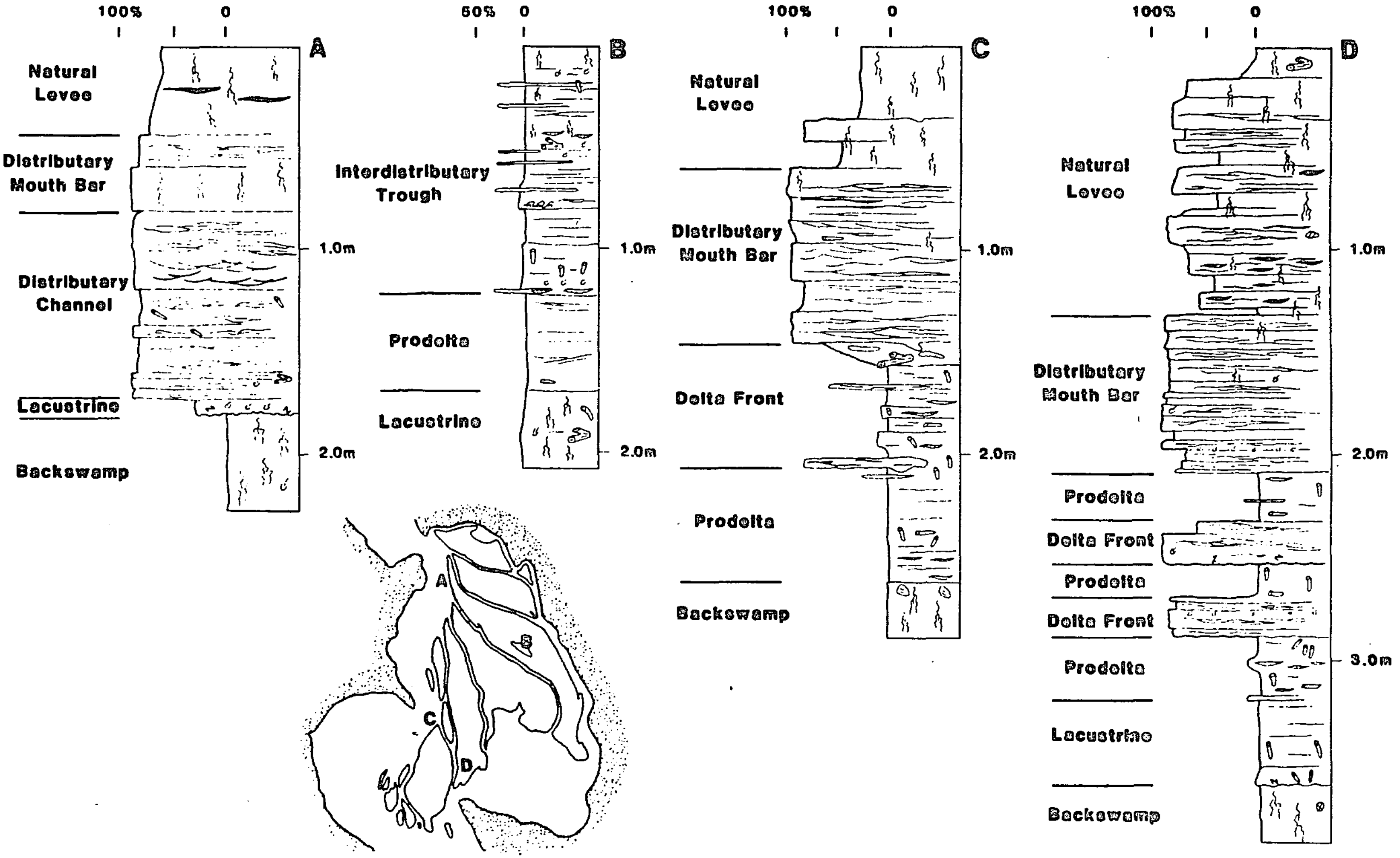
The question of differing sources for the red and grey sediments is still unresolved, but cores from Lake Fausse Pointe indicate that the coarsening-upward deltas were formed in a rather continuous manner. Red and grey clay deposits do occur in the basal section of the delta, but they are thinly to thickly interbedded and are not predictable in occurrence across the basin. Therefore, Fisk's (1952) lithounits most likely represent the basal lake bottom and prodelta overlain by the coarser-grained delta front and distributary mouth bar.

Vertical Sequences

Stratigraphic associations of depositional environments cored in the Lake Fausse Pointe delta generally fall into Fisk's (1952) lithounits, but vertical sequences are varied and more closely resemble the prograding deltaic sequence illustrated by Scruton (1960). Four vertical sequences (Fig. 18) illustrate some of the variability encountered in a lacustrine delta. They range from thick channel deposits scoured into the lake bottom, to fine-grained overbank deposits which have partially filled interdistributary troughs and overlie the prodelta. Two core profiles illustrate coarsening-upward sequences of prodelta, delta front, and distributary mouth bar, but also exhibit the varying degree to which these environments may interfinger.

Thick sand-rich channel deposits are most common in the proximal delta where channels are most numerous, receive the coarsest-grained sediments, and have had greater time to rework the delta deposits. Fine-grained interdistributary trough deposits form divisions between adjacent channels, isolating the linear channel, delta front, and distributary mouth bar sands. The classic coarsening-upward prodelta to distributary mouth bar sequences are deposited adjacent to the distributary channels, and form the bulk of the deltaic deposits. Fluctuations in depositional conditions or shifts in the

Figure 18. Representative vertical sequences from Lake Fausse Pointe. Thickness of the sedimentary column is indicative of the sand content (0 to 100 %) in the core. Core locations are given on the inset map, and correspond to: (A) proximal position in a distributary channel; (B) interdistributary trough; (C) updip apex of a distributary mouth bar lobe; and (D) downdip distributary channel bank.


100%
0
A
Natural Levee
Distributary Mouth Bar
Distributary Channel
Lacustrine
Backswamp
1.0m
2.0m
50%
0
B
Interdistributary Trough
Prodelta
Lacustrine
1.0m
2.0m
100%
0
C
Natural Levee
Distributary Mouth Bar
Delta Front
Prodelta
Backswamp
1.0m
2.0m
100%
0
D
Natural Levee
Distributary Mouth Bar
Prodelta
Delta Front
Prodelta
Delta Front
Prodelta
Lacustrine
Backswamp
1.0m
2.0m
3.0m
A
B
C
D

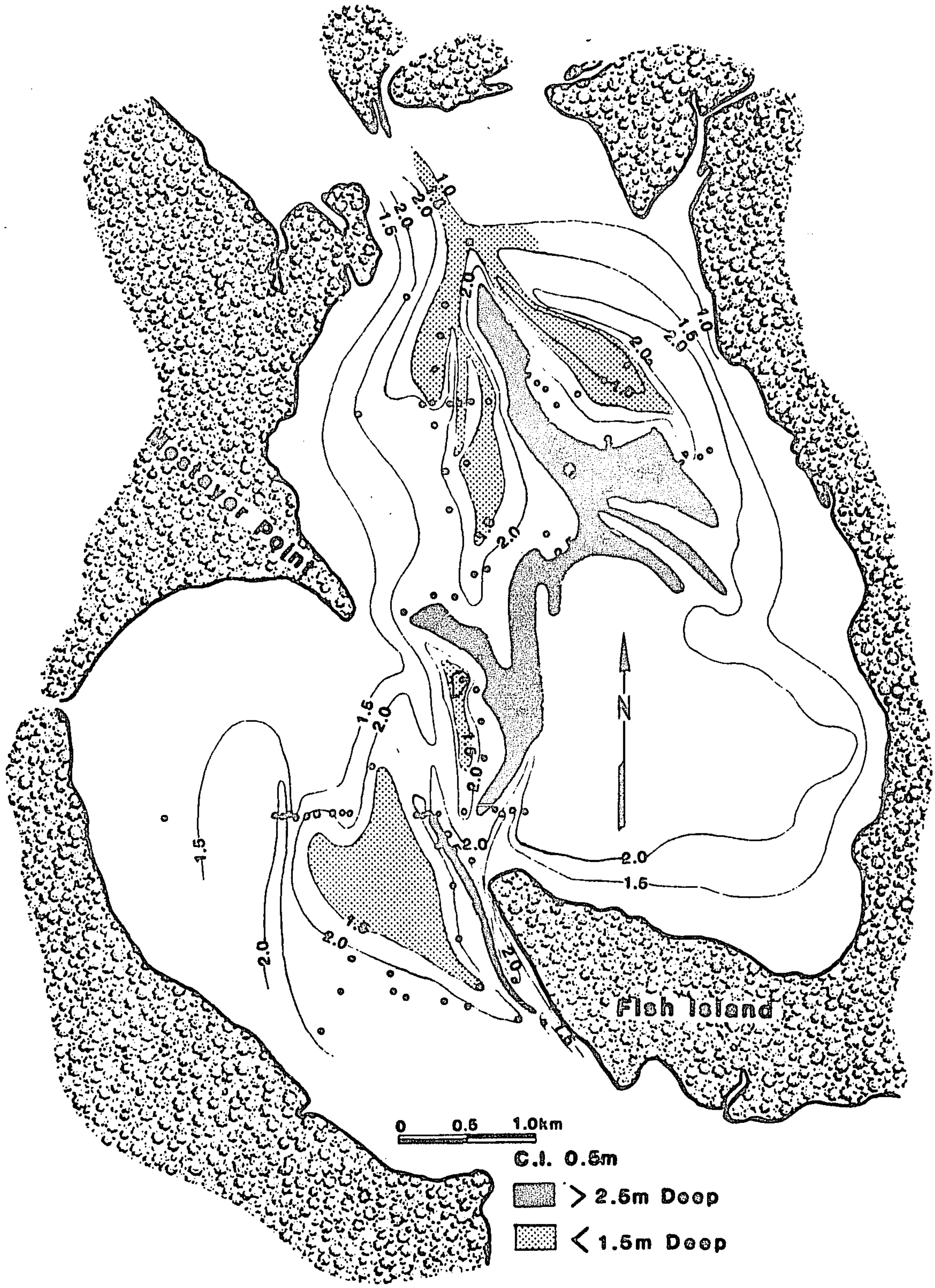
depositional site are indicated by the more highly inter bedded nature of cores located more distally in the delta.

Cross-Sections and Maps

Stratigraphic cross-sections, isopach maps, and a structure map of the backswamp surface over which the Lake Fausse Pointe delta prograded illustrate the occurrence, distribution, and association of lake delta environments. Paleotopography on the old backswamp surface greatly influenced delta stratigraphy. Relief on the backswamp surface averages 0.8 m and is attributed to the development of islands in the backswamp which, when submerged, formed isolated highs on the lake bottom. The irregularity of the lake bottom may be partially due to differential sedimentation, localized sediment compaction, and/or erosion in the backswamp. It is particularly significant due to the shallowness of Lake Fausse Pointe; the surface relief on the backswamp equals nearly one-third of the total depth of the lake.

The backswamp surface which forms the bottom of Lake Fausse Pointe is marked by a series of north/south trending ridges (Fig. 19). One bifurcating ridge at the apex of the lake extends through the upper one-third to one-half of the lake basin, dividing the lake into three relatively deeper areas. Ridges and lows have a branching to digitate morphology, but are essentially oriented parallel to depo-

Figure 19. Structure map on top of the paleo-backswamp surface depicts the lake bathymetry which influenced delta morphology. Lake depths are given relative to sea-level.


Fish Island
N
0 0.5 1.0km
C.I. 0.5m
> 2.5m Deep
< 1.5m Deep

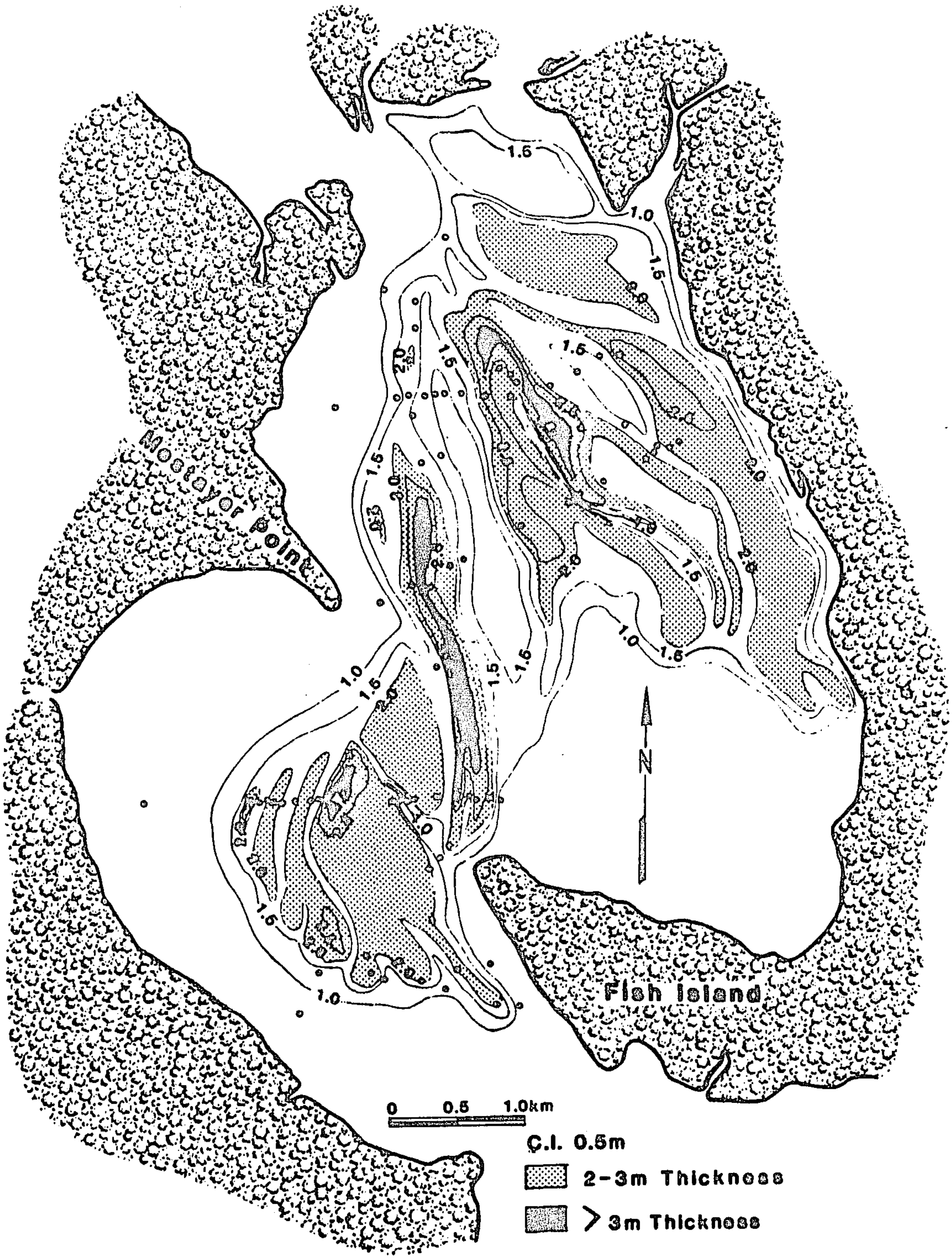
sitional dip. Depth to basement averages 1.0 to 1.4 m below mean water level on the ridges and 2.7 m in the low areas.

A central area with a maximum depth of 3.1 m below MWL was the deepest portion of the lake. It extended SSW to Fish Island and almost joined a NW/SE trending linear depression occupied by Bird Island Chute, the major distributary channel. Two north/south trending ridges and a broad platform to the north and west of Fish Island essentially form a rim along the western margin of the lake.

An isopach map of total delta thickness and a sand (>25% sand) isopach exhibit several obvious similarities in sediment distribution patterns and sandbody geometry (Figs. 20 and 21). Total delta thickness is directly proportional to the depth to the preexisting substrate. Thickest delta deposits closely follow the lows in the lake bottom. They form dip-elongate, linear to lobate sediment packages 2.0 to 6.0 km long and 0.4 to 1.3 km wide. Delta thickness is relatively consistent along dip, but is quite irregular along strike, mostly due to the occurrence of interdistributary troughs.

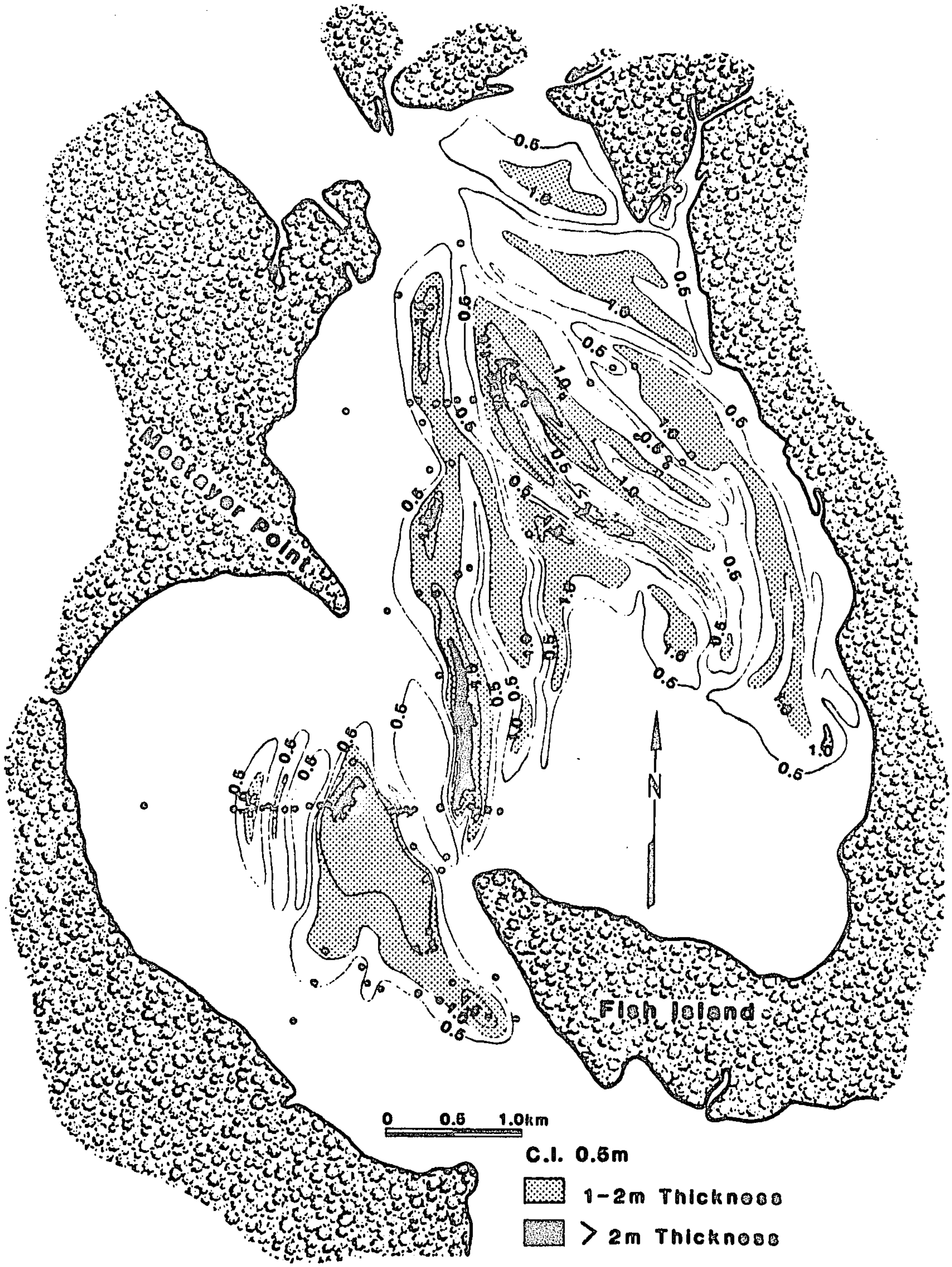
The sand isopach (Fig. 21) illustrates in greater detail the elongate nature of sand deposits in the delta. Horseshoe-shaped lobes occur in the central and southwest areas of the delta and sand thicks are present at their updip apex (Fig. 21). Linear sand ridges exhibit a tendency to thicken and thin, indicating that isolated distributary mouth bar sand pods were later joined together

Figure 20. Isopach map of total delta thickness.



Mostavor Point
Fish Island
1.0
1.5
2.0
N
0 0.5 1.0km
C.I. 0.5m
2-3m Thickness
> 3m Thickness

Figure 21. Isopach map of deltaic sediments containing greater than 25% sand.



Mostoyer Point
Fish Island
0 0.5 1.0km
C.I. 0.5m
1-2m Thickness
> 2m Thickness

by déposition and aggradation of natural levees (see ridge north of Fish Island; Fig. 21).

In cross-section, lake bottom deposits drape the backswamp basement, and generally thin and become more patchy in distribution downdip (Figs. 22 through 26). Areas devoid of lake bottom sediments correspond to the basement ridges. Shallow water depths and the large NW/SE

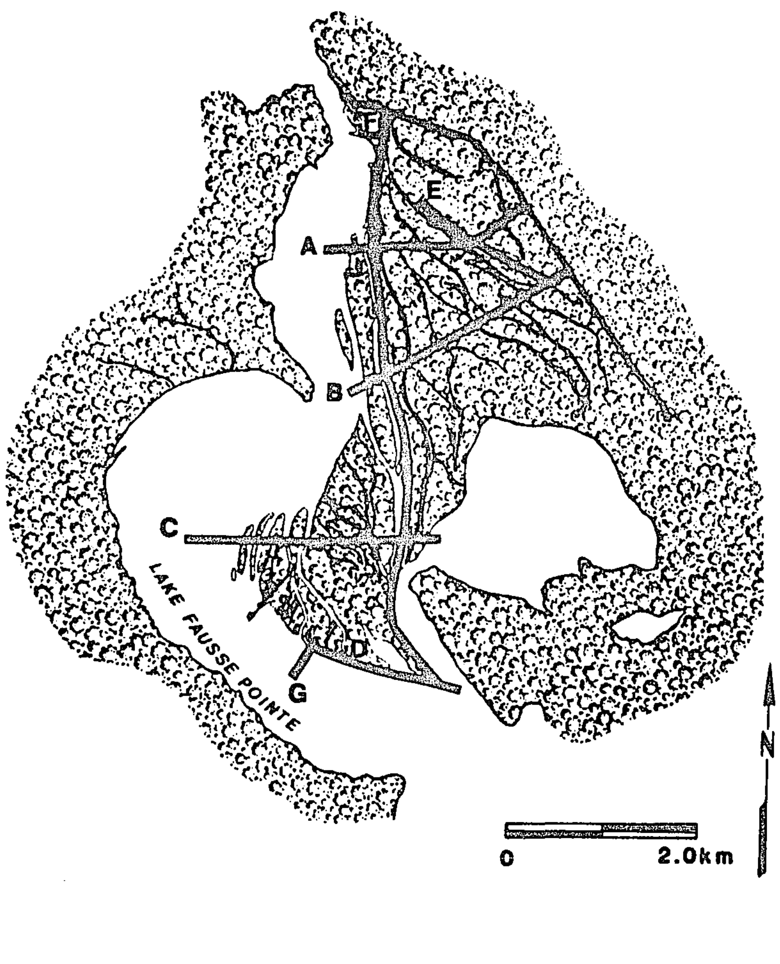


Figure 22. Location map for the stratigraphic cross-sections in Lake Fausse Pointe.

Figure 23. Strike-oriented stratigraphic cross-sections A and B illustrate the prodelta to distributary mouth bar delta sequence occasionally broken by interdistributary trough deposits. Note the decrease in occurrence of interdistributary troughs between sections A and B, and the low stratigraphic position of the easternmost deltaic deposits in section A.

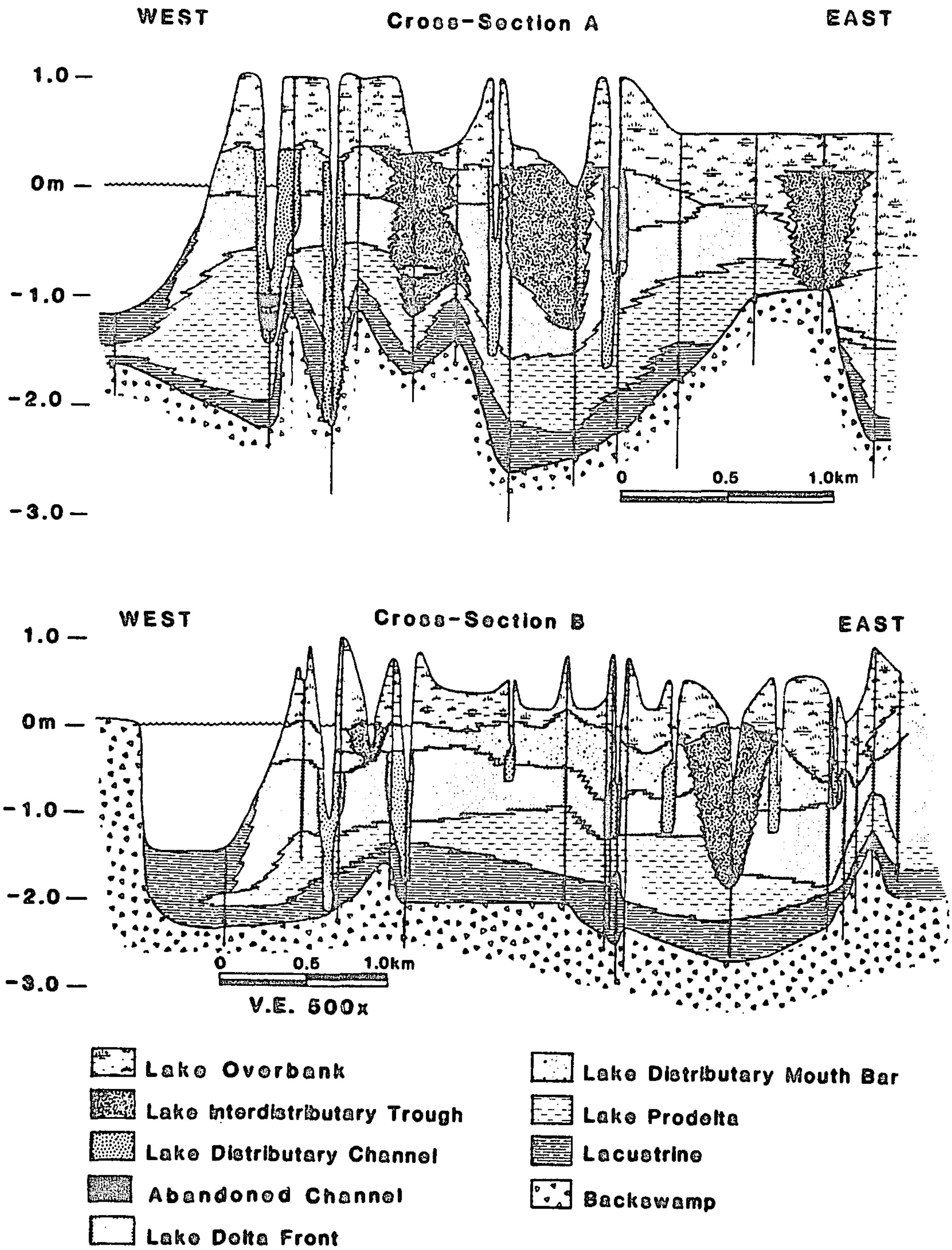
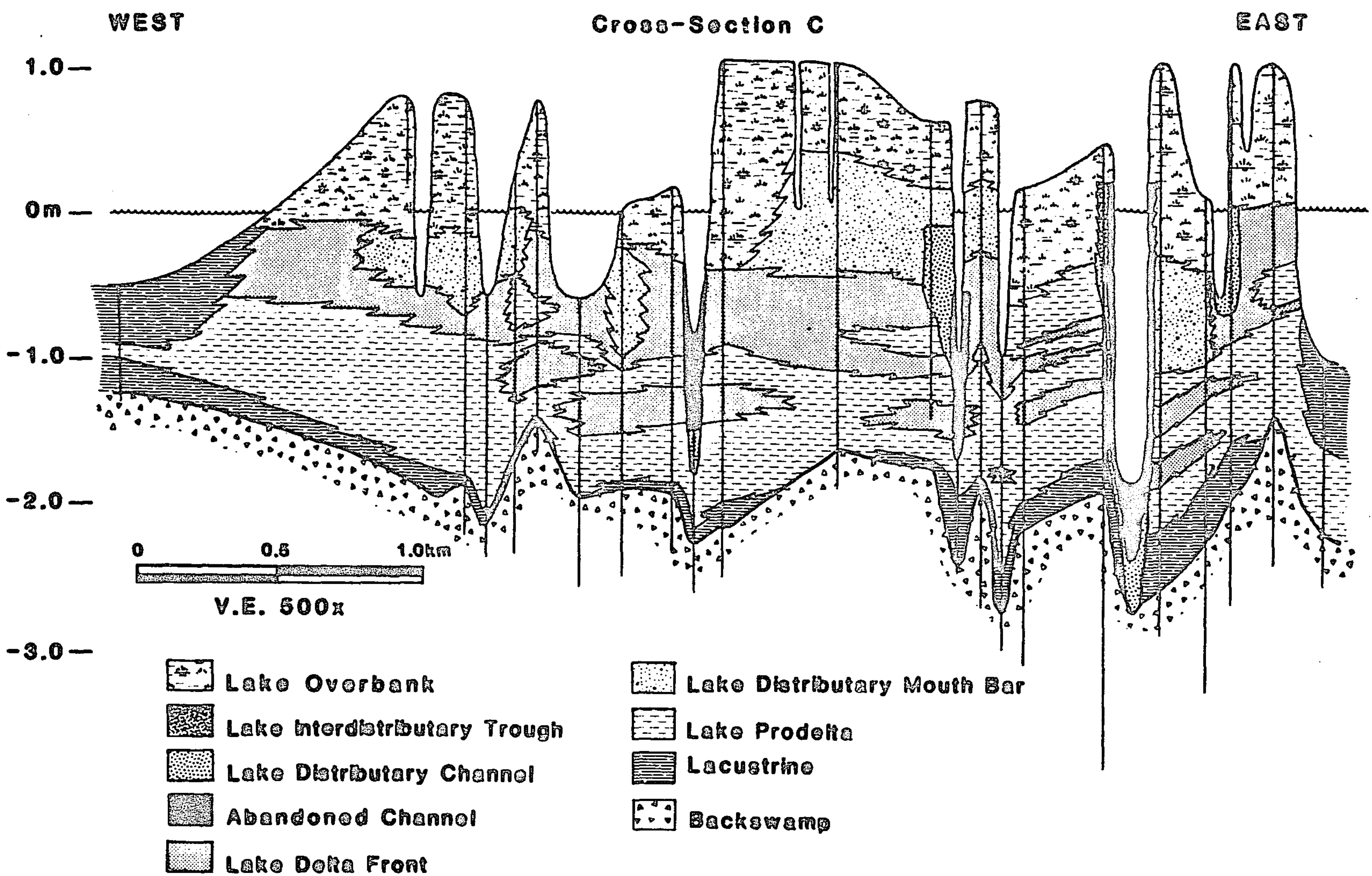

WEST
Cross-Section A
EAST
1.0
0m
-1.0
-2.0
-3.0
0
0.5
1.0km
WEST
Cross-Section B
EAST
1.0
0m
-1.0
-2.0
-3.0
0
0.5
1.0km
V.E. 500x
Lake Overbank
Lake Interdistributary Trough
Lake Distributary Channel
Abandoned Channel
Lake Delta Front
Lake Distributary Mouth Bar
Lake Prodelta
Lacustrine
Backswamp

Figure 24. Strike-oriented stratigraphic cross-section C illustrates the lateral discontinuity and multi-lobed character of the delta near its downdip extent. Note the interfingering of delta front and prodelta deposits.



WEST
Cross-Section C
EAST
1.0
0m
-1.0
-2.0
-3.0
0
0.5
1.0km
V.E. 500x
Lake Overbank
Lake Interdistributary Trough
Lake Distributary Channel
Abandoned Channel
Lake Delta Front
Lake Distributary Mouth Bar
Lake Prodelta
Lacustrine
Backswamp

fetch probably enhanced wave erosion on the backswamp, accounting for the absence of lake bottom sediments.

Prodelta, delta front, and distributary mouth bar environments have formed a progradational coarsening-upward sequence over the lake bottom. Prodelta mud gradationally overlies the lake bottom. This transition is not generally represented by a distinct lithologic or depositional break, as the lake periodically received prodelta sediments during floods, but reverted back to longer periods of quiet-water lacustrine deposition. Prodelta mud is laterally continuous along strike and dip throughout most of the delta. The gross thickness of the prodelta increases into depressions in the lake bottom. Downdip it thickens, but also is more strongly interbedded with delta front deposits.

Delta front and distributary mouth bar deposits gradationally overlie the prodelta. Three thick interdistributary trough clay plugs laterally interfinger with other deltaic deposits to separate the sandy delta deposits into four distinct lobes or packages (Fig. 23, section A) in the updip portion of the delta. The size of the interdistributary troughs generally decreases downdip, lessening the division of delta front and distributary mouth bar deposits (Figs. 23 and 24).

Delta front sediments interfinger laterally with prodelta and distributary mouth bar deposits. Isolated delta front lenses, sporadically distributed within the prodelta, represent occasional high-energy events in which coarser-grained sediments were transported further into the lake basin, and also reflect the periodic lateral shifting of the locus of deposition (Figs. 24 and 25, section D). Thin (0.1-0.25 m thick), restricted (0.1 - 0.8 km wide) delta front lenses in the upper prodelta attest to the gradational vertical and lateral changes between these environments. Uppermost delta front deposits exhibit greater continuity and reach thicknesses of 0.5 to 0.7 m.

Distributary mouth bars are variable geometrically and in distribution. Updip (Fig. 23, section A) and downdip (Figs. 24 and 25, section D), these deposits display a low degree of lateral continuity (0.2 to 0.55 km wide), whereas in the mid-delta (Fig. 23, section B), the distributary mouth bar is almost continuous across the delta. This probably reflects periods of slow versus rapid distributary progradation. Interdistributary troughs would be best developed during slow growth periods. Channels and interdistributary troughs form the major breaks between distributary mouth bars. Distributary mouth bars either overlie and/or are laterally equivalent to delta front, channel, and overbank environments. They are poorly developed updip, but thicken and attain good continuity downdip (Figs. 25, section E and 26). Thickest distributary mouth bars form where several channels are closely associated and several individual mouth bars coalesce into one.

Figure 25. Strike-oriented (D) and dip-oriented (E) cross-sections.

Section D is located at the downdip extent of the delta and illustrates the complete progradational delta sequence. Note the sparse occurrence of lake bottom sediments.

Section E illustrates the downdip thickening of the delta and the strongly interfingering delta front and prodelta.

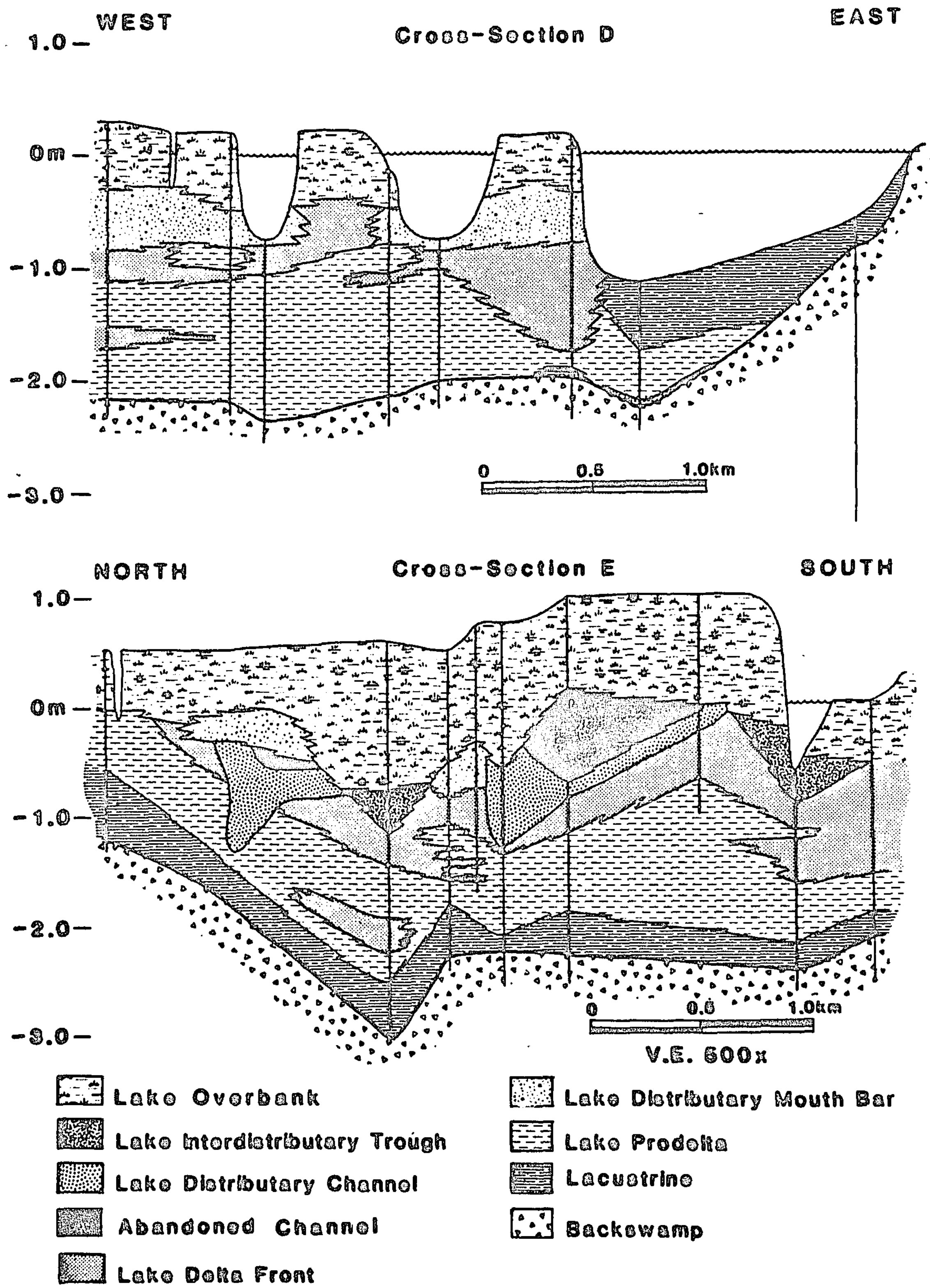
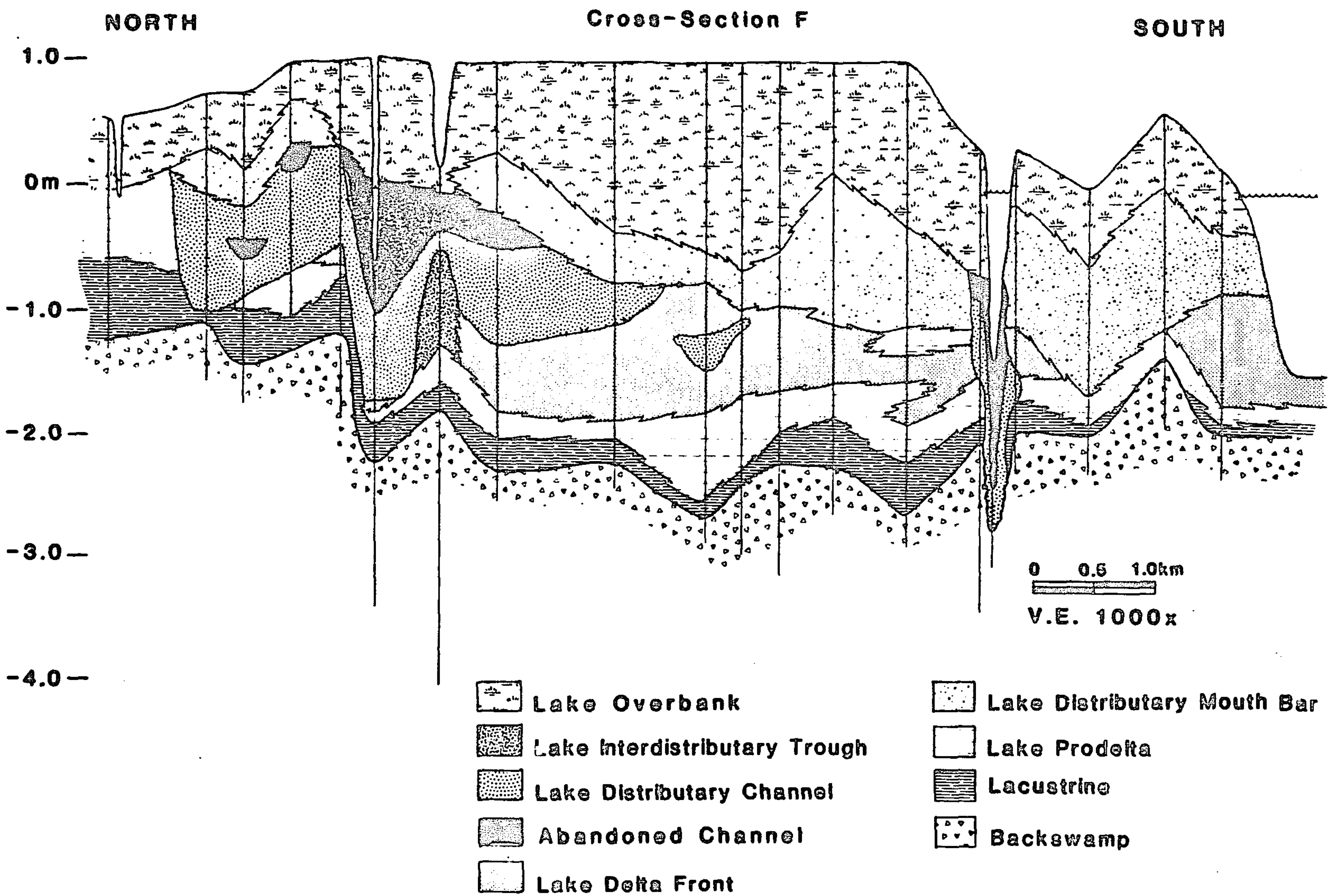

WEST
Cross-Section D
EAST
1.0
0m
-1.0
-2.0
-3.0
0
0.5
1.0km
NORTH
Cross-Section E
SOUTH
1.0
0m
-1.0
-2.0
-3.0
0
0.5
1.0km
V.E. 500x
Lake Overbank
Lake Interdistributary Trough
Lake Distributary Channel
Abandoned Channel
Lake Delta Front
Lake Distributary Mouth Bar
Lake Prodelta
Lacustrine
Backswamp

Figure 26. Dip-oriented stratigraphic cross-section F follows the Bird Island chute distributary channel from the delta apex to its downdip extent. Note the dominance of channel deposits in the proximal delta (north) which are replaced by thickening distributary mouth bars downdip.


NORTH
Cross-Section F
SOUTH
1.0
0m
-1.0
-2.0
-3.0
-4.0
0 0.5 1.0km
V.E. 1000x
Lake Overbank
Lake Interdistributary Trough
Lake Distributary Channel
Abandoned Channel
Lake Delta Front
Lake Distributary Mouth Bar
Lake Prodelta
Lacustrine
Backswamp

Distributary channels incised in delta front and prodelta sediments are best developed in the upper portion of the delta (Fig. 23, section a). Deposits tend to be deeply scoured (1.45 to 2.15 m below MWL), and rarely are entrenched in the underlying backswamp clay (Figs. 23, section A, and 24), although lake bathymetry has clearly influenced the location and morphology of the largest channels. Channel deposits are narrow, dip-oriented ribbons of sand and mud. Most channels are narrow, symmetrical, vary in width from 0.15 to 0.20 km, and thus are greatly restricted along strike. When viewed along dip, channels exhibit a greater degree of continuity. They represent the thickest sand accumulation in the proximal (updip) delta; implying greater channel reworking of deltaic sediments than in the downdip (distal) areas of the delta.

DISCUSSION

Structural features in south-central Louisiana controlled the position and morphology of the entrenched Pleistocene drainage system (Fisk, 1944). The topography of this entrenched valley has, in turn, influenced the morphology of the present alluvial valley and delta plain which formed by alluviation of the entrenched valley during the Holocene sea-level rise. Structure maps on the Late Pleistocene Mississippi Valley surface, and fault maps (Fisk, 1944, 1952; McCulloh et al., 1984) indicate that Pleistocene drainage patterns were influenced by the Red River Fault Zone and Five Island Structural Axis (Fig. 5), and that the Atchafalaya Basin formed partially in response to being isolated in this entrenched valley. More importantly, is the close relationship implied between the Pleistocene drainage patterns and the presence of large lakes in the Recent topstratum (Fig. 5).

Fisk (1952) discounted lake formation through differential sediment accumulation, which might have occurred in response to small-scale faulting in the topstratum. Instead, he felt that all irregularities in sediment geometries were caused by paleotopography. Indeed, the alignment of numerous geomorphic features in a NW/SE orientation suggests strong paleotopographic control on Holocene drainage patterns and basin morphology.

Lake Evolution and Initial Delta Growth

Russell (1936, 1942b) noted that lakes in coastal Louisiana are initially formed by subsidence (subsidence is in part a function of the depth to the Pleistocene; Roberts, 1986), and that their size increases as subsidence is augmented by wave erosion on the lake margins. Regional subsidence is induced in the Gulf of Mexico by the depositional loading of the Mississippi River. In addition, variations in subsidence rates occur due to localized sediment compactional differences and the depth to the Pleistocene.

Fine-grained sediments and organic debris accumulated in deeper areas of the incipient Lake Fausse Pointe as the backswamp surface was depressed and gradually inundated. Sandy to silty sediments were concentrated by waves around the lake rim and, as the lake grew in area, lake sediments transgressed the backswamp surface. Intraclasts of backswamp clay and broken *Rangia cuneata* valves were reworked into the lake bottom sediments by periodic storms and hurricanes. Lake Fausse Pointe ultimately reached a maximum depth of 2 to 3 m; a sufficient size and depth to support steamboat transportation as recently as the 1880's (Howe and Moresi, 1931; Fig. 27a).

Once Grand Bayou began to consistently deliver sediment to Lake Fausse Pointe, an unstable density relationship between the sediment-laden inflowing water and the fresh ambient lake water developed in what had previously been a well-mixed, unstratified lake. A density contrast between the more dense sediment/water plume and ambient lake water created hyperpycnal flow conditions (Bates, 1953), with underflows capable of scouring the prodelta and backswamp. That density-driven underflows set up by floods or large rainstorms existed in Lake Fausse Pointe can be inferred from the bottom-hugging nature of the major channels, their low stratigraphic position in relation to delta front and distributary mouth bar deposits, the repeated occurrence of thin (5 to 10.0 cm), sharp-based, normally graded deposits of sand to silt or clay, and the occasional inclusion of thin, flood-emplaced coarser-grained beds in distal portions of the delta. Lambert and Hsu (1979) and Weirich (1986) have monitored similar lacustrine underflows in Switzerland and British Columbia, respectively. Bogen (1983) has suggested that turbidity currents are more likely to form in low-angle deltas, when inflow velocity is low, and therefore turbulent mixing of the water masses is reduced.

The triangular, wedge-shaped form of the Lake Fausse Pointe delta was partially controlled by the slope and bathymetry of the confined basin (Fig. 28a). Underflows initially flowed into and followed the deepest portions of the lake, were deflected to the east by bathymetric ridges, and deposited delta front and distributary mouth bar lobes at their downdip limits (Fig. 27b and 28b). The magnetude of depositional events in the lake was largely controlled by the discharge and sediment load of the Atchafalaya River.

With continued sedimentation, the site of downdip delta front/distributary mouth bar lobe formation by underflows shifted to the west, most likely in response to the hydraulic gradient (Fig. 27c). Simultaneous with the westward shift, sedimentation occurred on the apex of the previously deposited lobes in the form of subaqueous levees. Once established, these levees channelized flow, aggraded through overbank deposition, and initiated updip delta growth. The resultant geomorphic features, similar to mid-channel bars, separate the distributary channels. Delta building continued with a progressive westward shift and southward progradation of four individual lobes (Fig. 27d). Through downdip lobe deposition, aggradation and welding of smaller lobes, and updip growth of distributary mouth bar and overbank deposits, upper Lake Fausse Pointe was essentially filled in reverse (Fig. 28c). Once the underflows had established the depositional lobes and flow was confined by suberial levees, downdip progradation was subordinate to vertical delta accretion and updip growth. A similar progression of events was observed in the Atchafalaya Delta by van Heerden (1983).

As the entire delta was deposited very rapidly, the actual age differences between the lobes are small, but slight differences in their morphology, orientation, and stage of development are evident. Lobes three and four

Figure 27. Evolutionary sequence for the Lake Fausse Pointe delta.

(A) Corresponds to 1919 and illustrates that subaerial delta growth had not occurred. From Mann and Kolbe (1912) and Meyer and Hendrickson (1919).

(B) Corresponds to a 1931 map by Howe and Moresi and illustrates the initial downdip formation of delta front/distributary mouth bar lobes.

(C) Hypothetical intermediate stage in delta development. Some delta lobes have coalesced and begun to accrete updip.

(D) A 1932 USGS topographic sheet illustrates the maximum growth of the Lake Fausse Pointe delta. The delta was artificially abandoned (1932-1934) by levee construction. Four major depositional lobes are noted.


A
B
C
D
Lake Fausse Pointe
0
2.0km
1
2
3
4

(Fig. 27d) exhibit later stages of delta growth and have less well-developed channels and distributary mouth bar ridges. Multiple lobes also comprise the Grand Lake delta as illustrated in great detail by Fisk (1952).

Delta Morphology and Stratigraphic Implications

Prograding coarsening-upward prodelta to distributary mouth bar deposits have become the standard sedimentary sequence or "model" associated with deltas, despite the wide-ranging character of depositional sequences that are possible in varied deltaic settings. Coleman and Wright (1971; 1975) have attributed morphologic and stratigraphic differences in deltas to the interrelationships of multiple processes ranging from basin tectonics and hydrographic regime, to sediment load and discharge.

Lacustrine deltas have, since Gilbert (1885), immediately brought to mind the classic tripartite sequence of bottomset, foreset, and topset beds formed by progradation of a clastic sediment wedge into a standing lake body. This sedimentary scheme has been used in interpretations of ancient lacustrine rocks (Carrigy, 1971; Born, 1972; Stanley and Surdam, 1978; Surdam and Stanley, 1979), although relatively few modern examples of Gilbert deltas have been studied (Boothroyd and Ashley, 1975; Gustavson et al., 1975; Dunne and Hempton, 1984). Syvitski and Farrow (1983) have established that differences in

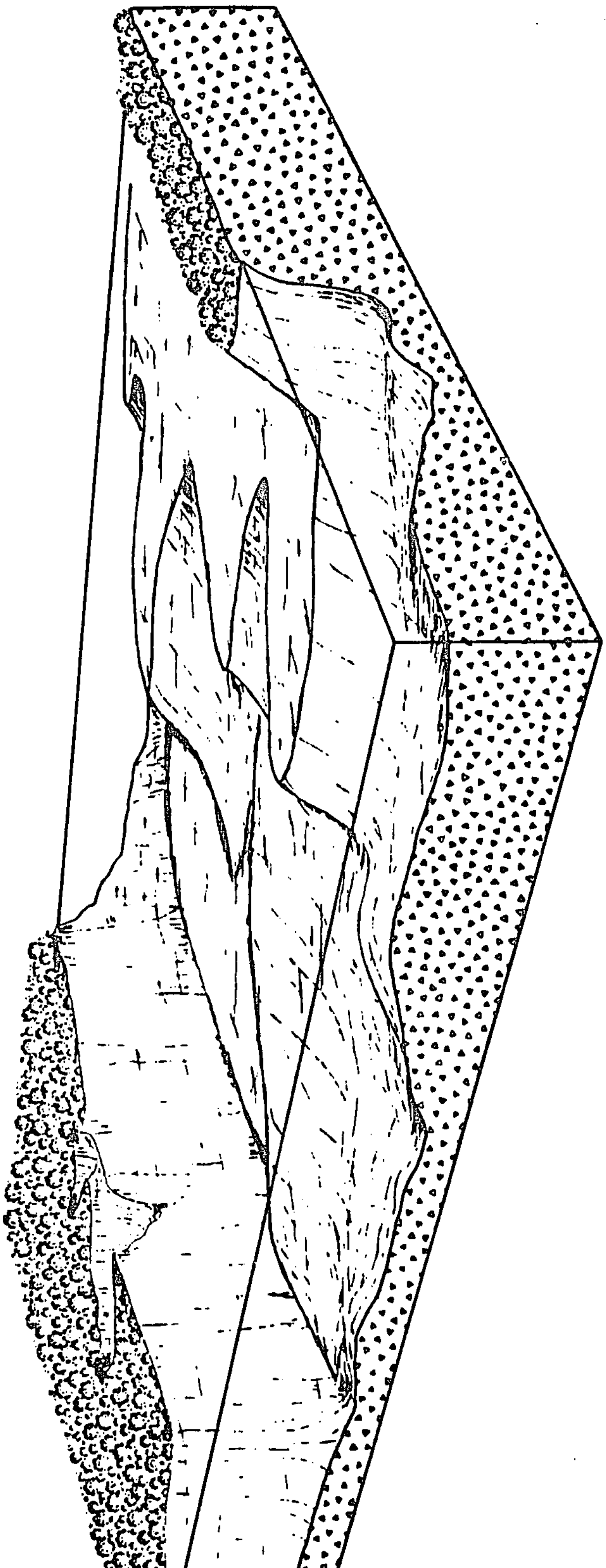
Figure 28. (A) Hypothetical representation of Lake Fausse Pointe and its bathymetry prior to deltaic deposition.

(B) Intermediate stage of delta evolution illustrating the morphology and sequential deposition of the delta lobes. Arrows depict the pathways of hyperpycnal underflows.

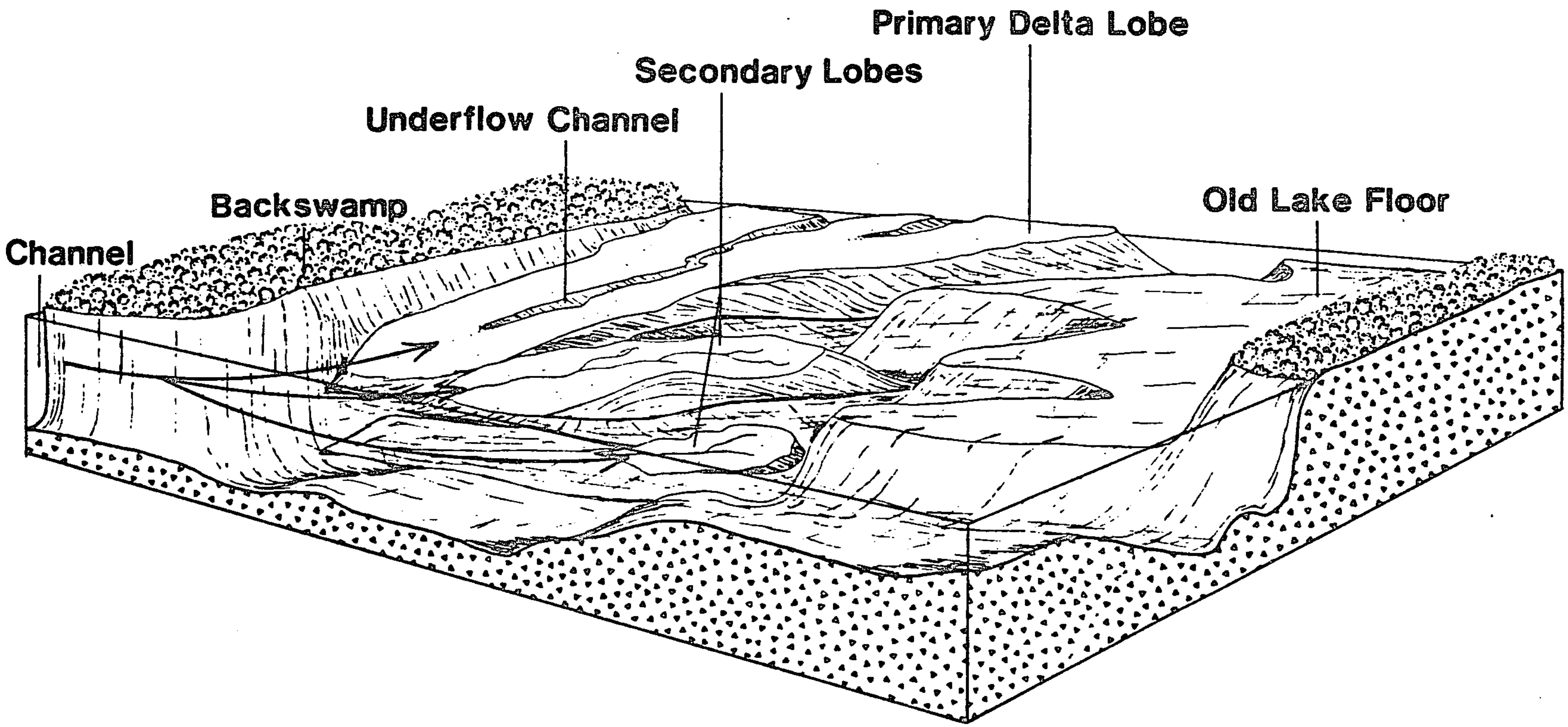
(C) Complete development of the Lake Fausse Pointe Delta and its distribution of environments along depositional strike and dip.

View is approximately to the northeast. No scale intended.

A

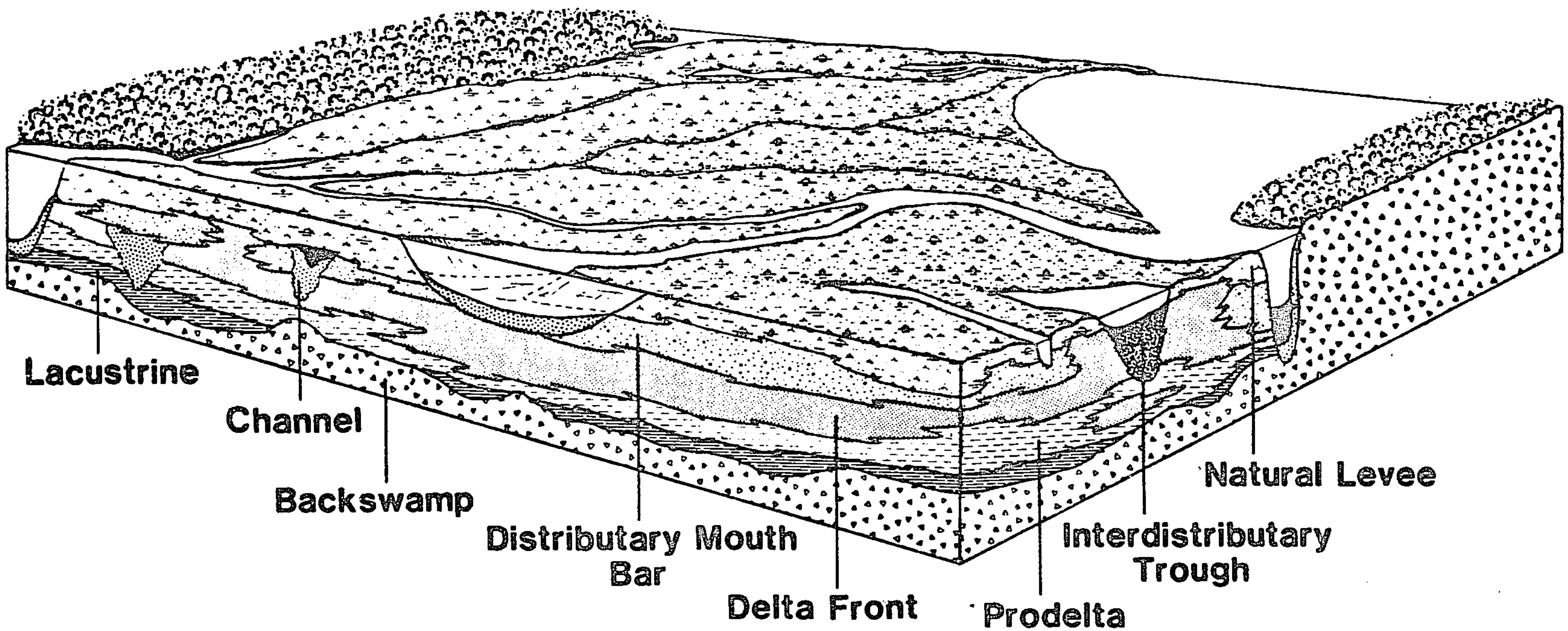


B



Primary Delta Lobe
Secondary Lobes
Underflow Channel
Backswamp
Channel
Old Lake Floor

C


Lacustrine
Channel
Backswamp
Distributary Mouth Bar
Delta Front
Prodelta
Interdistributary Trough
Natural Levee

processes may exist within one basin such that both Gilbert deltas and distributary mouth bar deltas may co-exist. The Gum Hollow delta (McGowen, 1970) may also be analogous to a Gilbert delta as sedimentation is controlled by braided streams and sheet floods on the delta plain.

The stratigraphy and geomorphology of the Lake Fausse Pointe delta obviously do not resemble the freshwater lake delta deposits described by Gilbert (1885). Large-scale differences in regional tectonics, sediment source, topographic relief, climate, basin morphology, and hydrology determine the geologic character of the delta. Therefore, in a low-relief, fluvially dominated basin in which a strong density contrast between the inflowing river/sediment plume and lake water exists, "non-Gilbert type" deltas are most likely to form. As sea-level fluctuations influence topographic relief in alluvial basins, periods of low sea level may coincide with periods of greater development of Gilbert deltas; whereas, during high sea level stands, lacustrine deltas would more closely resemble the Lake Fausse Pointe delta.

Few subsurface studies of modern lacustrine deltas have been undertaken, but in relation to the Lake Fausse Pointe delta, the East Texas bayhead deltas, the Lake Laitaure delta, the Catatumbo delta, and the Lake Hazar distributary channel deltas exhibit some sedimentologic and stratigraphic similarities, especially in the vertical arrangement of their prograding depositional environments.

Tectonic, climatic, geomorphic, and hydrologic processes vary widely among these depositional sites, and thus differences in the occurrence, distribution, and lateral associations of sedimentary environments occur.

Aside from the topographic and bathymetric influences, in a freshwater, tideless basin with relatively low wave energy, the river mouth processes of inertia and friction influence the delta form and sand distribution within the delta lobes (Coleman and Prior, 1980). In Lake Fausse Pointe, inertia was sufficiently strong enough to extend the plume several km downdip forming linear, dip-elongate sand bodies (Figs. 20 and 21). As velocity and inertia decreased, friction between the plume and lake bottom came into play. Rapid sediment fallout, a result of loss in current velocity, aggraded the distributary mouth bar crest. Confinement of the sediment plume between levees inhibited expansion of the plume, and resulted in distributary channel bifurcation (Welder, 1959; Coleman and Prior, 1980). Several channel bifurcations not induced by bathymetric control are partially evident in the distal portion of the delta (Fig. 4). Therefore, thickest sand deposits occur parallel to distributary channels, at the apex of distributary mouth bars between bifurcating channels, and as individual pods along the linear trend (Fig. 21).

Although formed under extremely different climatic conditions, the Lake Laitaure and Lake Fausse Pointe deltas have many similar geomorphic features. Both deltas were formed in freshwater lakes by rivers which episodically introduced large quantities of sediment. Axelsson (1967) determined that hyperpycnal conditions could exist in Lake Laitaure with density differences between inflowing and ambient waters as low as 0.0008 to 0.0003 g/m^3. A few number of elongate distributaries, with occasional channel bifurcations, and large interdistributary troughs comprise a delta plain very similar to the Lake Fausse Pointe delta. Unfortunately, no subsurface data is available for the Laitaure delta.

The east Texas deltas all prograded rather rapidly (except the Guadalupe) into shallow, saline, protected basins. Except for the Guadalupe delta, confinement by the receiving basin was not a factor controlling the delta shape (Donaldson et al., 1970). In cross-section, these deltas, and even the presently building Atchafalaya delta, exhibit remarkably similar stratigraphies of multi-lobed prodelta to distributary mouth bar deposits cut by channels. Interdistributary bays or algal flats may laterally disrupt the sand continuum (Donaldson et al., 1970; Kanes, 1970; van Heerden, 1983). Figure 29 compares isopach trends from the Colorado delta, Guadalupe delta, and the Lake Fausse Pointe delta (modified from Donaldson et al., 1970 and Kanes, 1970). In cross-section, only minor differences are evident between the deltas, such as the presence of poorly developed and restricted delta front

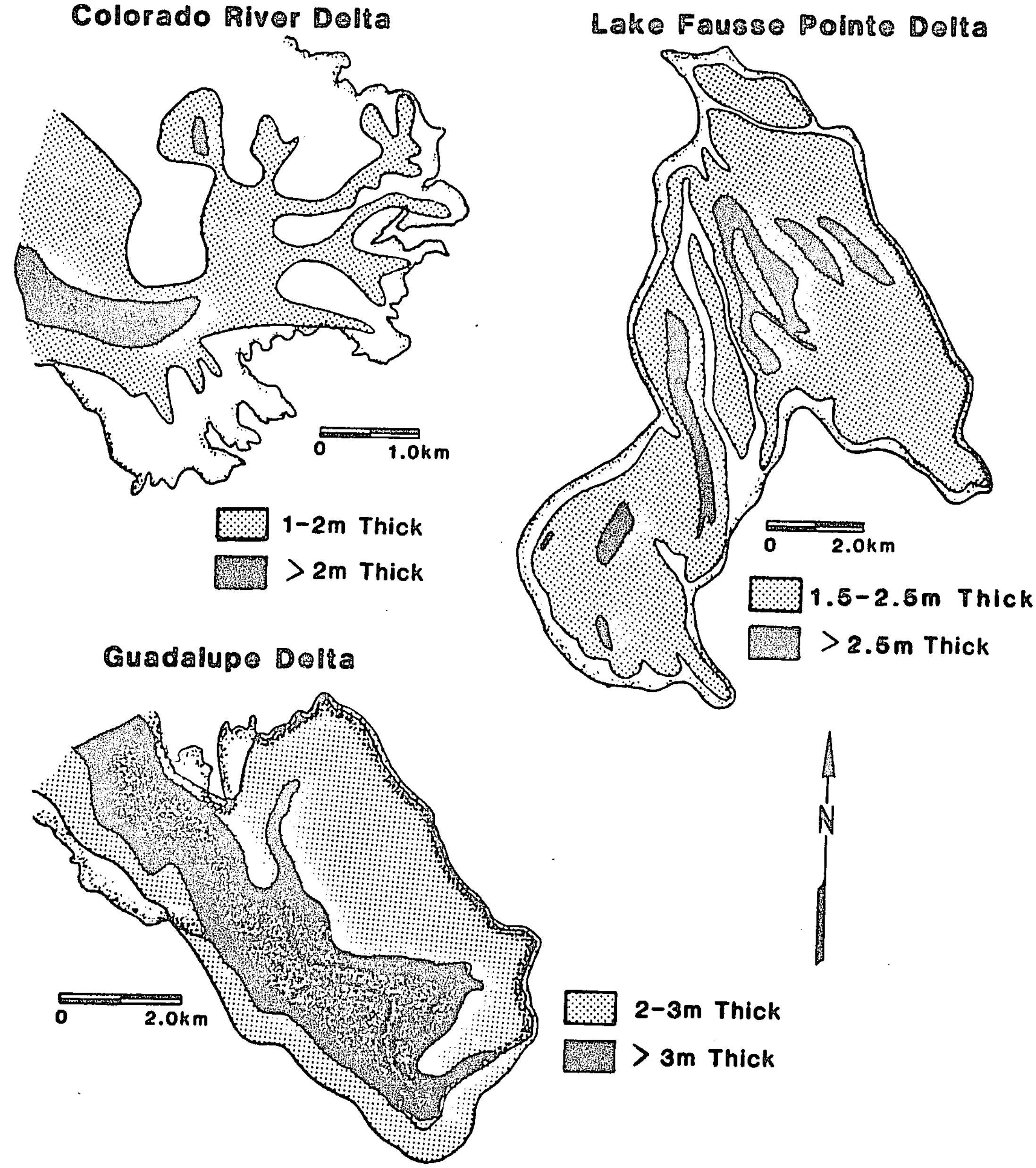


Figure 29. Comparison of sediment distribution and thickness between two bay-head deltas in Texas and the Lake Fausse Pointe delta. Differences in isopach patterns are a function of river mouth processes and basin bathymetry.

deposits in the Guadalupe delta. This could be attributed to differences in interpretation, but the major subsurface differences between these deltas and the Lake Fausse Pointe delta only become apparent in comparisons of sand distribution.

Differing river mouth processes are largely responsible for the variability between these deltas. Saline lagoonal water, into which the Texas deltas and the Atchafalaya delta prograded, reacted with the inflowing plume and created hypopycnal conditions, which, when combined with frictional forces at the plume/bay boundary, resulted in deposition of lobate distributary mouth bars with highly bifurcating channel networks. Therefore, sand distribution patterns for the Guadalupe, and especially the Colorado deltas, closely resemble the branching bird-foot morphology described by Fisk (1961), rather than the elongate, linear sand deposits in Lake Fausse Pointe. Kanes (1970) proposed that the Colorado delta initially formed as a sandsheet of coalesced distributary mouth bars. Progradation of a later delta lobe created a digitate morphology of long sand fingers. Bernard and LeBlanc (1965) and Donaldson et al. (1970) have classified the Guadalupe delta as compounded birdfoot-lobate, owing to differences in lobe morphology most likely induced by the San Antonio/Guadalupe Bay bathymetry.

Lake Delta Cyclicity

Delta progradation into interdistributary basin lakes is a relatively short-duration episode, but deep borings in the Atchafalaya Basin indicate that lake delta deposition is repetitious in nature. This study of the Lake Fausse Pointe delta documents the processes of lake infilling, the occurrence and distribution of deltaic environments, and their stratigraphy. The geologic character of this delta can be used as a foundation for analyzing the formation and importance of lake deltas during the evolution of the most recent topstratum deposits.

Lakes are constantly forming in response to high subsidence rates in the alluvial valley but, because they are rapidly filled by terrigeneous clastic sediment influx, lakes associated with fluvial systems are ephemeral features. Lacustrine deltas form the updip and lateral depositional equivalents to the marine delta lobes deposited by the Mississippi River. As Fisk (1952) and Roberts et al. (1980) have shown, prior to depositing a marine delta, the Atchafalaya distributary had to alluviate its valley. This was accomplished partially through aggradation of the backswamp, but largely through filling of the lakes in the lower basin with prograding clastic sedimentary deposits. Certainly, the developing Atchafalaya River will rework portions of these deltas in the process of building a marine delta and in increasing the size of its meander belt, but the lake deltas represent a significant volume of terrigenous clastic sediment within the lower alluvial basin. (Deposition in Grand Lake during the period from 1918 to 1978 equalled roughly 234 m^3/m; Army Corps Engineers, Pers. Communication).

Once allochthonous sedimentation began, the lakes in the lower Atchafalaya Basin filled rapidly. The Grand Lake and Lake Fausse Pointe deltas prograded at rates of 1.1 and 2.0 km/yr, respectively. Sedimentation rates for prodelta to overbank sequences in Lake Fausse Pointe average 16.0 cm/yr, but actual accumulation rates were probably highly sensitive to flood intensity on the Atchafalaya River.

Upon complete delta progradation and filling of the lake, the regressive sedimentation phase was completed. In the case of Grand Lake, the Atchafalaya River has established its preferred channel, and the site of active deposition has bypassed the lake delta. Essentially, the delta has been abandoned except for lateral reworking by the Atchafalaya River and overbank deposition. At this point in the delta's evolution, overbank deposition is initially sufficient to partially fill the interdistributary troughs and aggrade the delta plain. A backswamp soil develops on the delta surface, and occasional overbank deposition enhances the lateral gradation of the delta plain and the existing backswamp margins. As sedimentation slows due to delta abandonment, a crucial point is reached where sedimentation alone cannot keep pace with subsidence.

Following lake delta abandonment, a minor amount of overbank sediment, in conjunction with organic accumulation in the backswamp, can offset subsidence and maintain a subaerial surface. Data on accumulation and preservation rates of organic material in swamps are sparse (Conner et al., 1981; Scheibing and Pfefferkorn, 1984), but Hatton et al. (1983), Delaune and Smith (1984), and Kosters et al. (in press) have determined that organic accumulation rates in fresh to brackish marshes and subsurface organic accumulation in true peat swamps average 1.3 to 0.05 cm/yr. Accumulation rates are variable and highly influenced by the dominant environmental processes (Patrick, 1981; Delaune et al., 1981). Through sedimentation and organic buildup, the subsidence rate must be maintained at a level at which the vegetation can keep pace. Vertical aggradation is further inhibited by the destruction of organic matter in the soil. Alexander (1977) has stated that two to five percent of the carbon in humus can be degraded per year, although higher residual organic levels are usually found in bottomland soils because of greater organic production and the presence of organic/clay interactions and anerobic conditions which retard decomposition (Patrick, 1981; Delaune et al., 1981).

Once subsidence is accelerated due to decreased sedimentation and microbial degradation of organic materials in the soil, vegetation in the backswamp environment will ultimately be stressed to the point of destruction. Continuous flooding of the backswamp may occur through channel avulsion or delta lobe abandonment and induces anerobic conditions which stress the vegetation (Wharton et al., 1982). Flood-intolerant species quickly die in permanently flooded swamps; in addition, organic production and species rejuvenation decrease because fewer trees remain (Conner et al., 1981). Even flood-tolerant trees are unable to germinate when permanently flooded (Penfound, 1952). Subsequent swamp destruction may occur in 200 to 300 years (Conner, pers. communication). Destruction of the backswamp forest in combination with basin subsidence and low sediment input results in progressive flooding of the delta plain and the creation of a new lake.

Cyclic lacustrine sedimentation is largely driven by subsidence in the alluvial valley. In backswamps, only locally derived silt, clay, and organic matter accumulate, and with a subsidence rate of 1.4 cm/yr in the lower Atchafalaya Basin (Roberts, 1986), this sediment input is inadequate to maintain a subaerial surface. Thus, the backswamp is drowned, and the transgressed backswamp surface represents a disconformable surface at the base of the lake sequence. Following inundation, reworked siliciclastics and *in situ* organic matter accumulate in the lake bottom. Although chemical precipitates were not observed in Lake Fausse Pointe, this phase of lacustrine sedimentation is analogous to the autochthonous or chemical cycles described by Van Houten (1964), Picard and High (1981), and Yuretich et al. (1984).

Deltaic sedimentation represents a lake-filling (detrital or allochthonous) episode. Coarsening-upward sequences are often equated with this regressive phase, but fining-upward (abandoned distributary channel) or mud-rich (interdistributary trough) sequences comprise a significant portion of the sediment package. The preserved facies tract represents progressively shallower-water conditions upward, however, the lake did not undergo major water-level fluctuations (drying). With subsequent transgression and lake filling by another deltaic body, the morphology and sediment distribution patterns of the younger delta will be controlled by the antecedent topography formed by the preceding delta and backswamp deposits. In this manner, sandy lake delta sequences are stacked vertically and laterally.

Regressive deltaic sequences represent a very short period in geologic time; their sedimentary thickness constitutes an appreciable portion of the overall basin-fill. Backswamp and lake bottom deposits form under conditions of much slower sedimentation, and therefore, their sedimentary thickness represents considerably longer time periods.

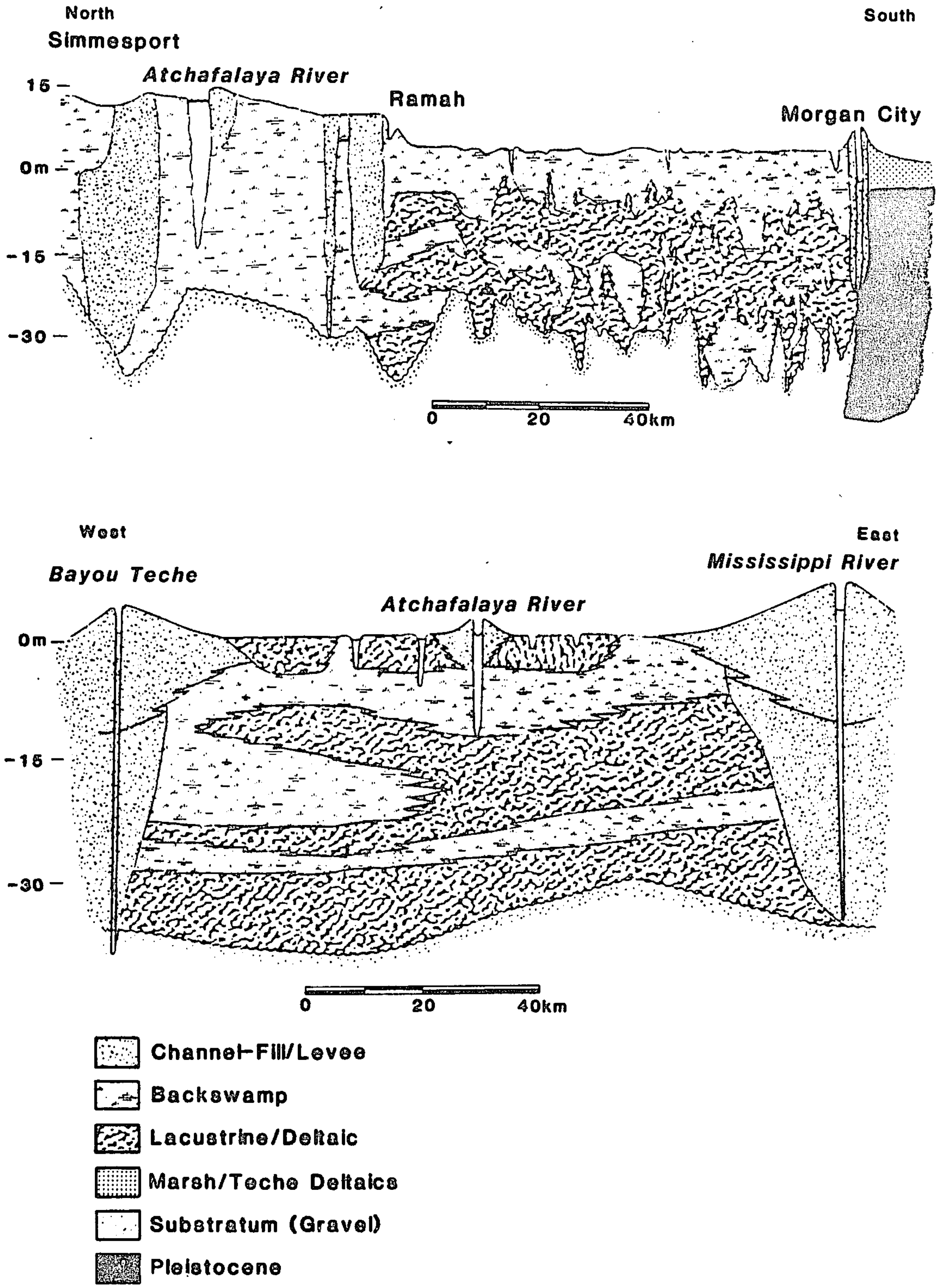
Evolution of Atchafalaya Basin Topstratum

Fisk (1952) and Smith et al. (1986) have described the geologic scenario for the formation of the Atchafalaya Basin. Cross-sections through the basin (Fig. 30) reveal the repetitious nature of lacustrine sediments (with lake deltas) and backswamp deposits in the 30 m thick topstratum. Radiocarbon dating (Smith et al., 1986) indicates that this topstratum sequence is less than 10,000 years old, and that the upper 9.0 m are related to the Teche (approximately 5800 years B.P.) or younger distributaries.

No basal transgressive marine section has been described in the Atchafalaya borings from north of Morgan City (Fisk, 1952; Coleman, 1966; Roberts, 1986). However, seaward of the Teche meander belt, Fisk (1952) described deltaic deposits overlying the Pleistocene (Fig. 29), and Roberts (1986) encountered bay sediments of possible marine origin southeast of Morgan City. With sea-level stabilization, basin alluviation progressed through deposition of lacustrine, backswamp, and marsh deposits.

Strike- and dip-oriented cross-sections through the Atchafalaya Basin (data from Fisk, 1952 and Krinitzsky and Smith, 1969) illustrate the complex facies associations in the topstratum. Lacustrine deposits initially filled the depressions in the substratum surface. Swamp occurrence is generally correlatable to paleotopographic highs, but does

Figure 30. Schematic dip- and strike-oriented cross-sections through the topstratum section of the Atchafalaya Basin illustrate the repeated occurrence of lacustrine and backswamp deposits in this 30 m thick section of Holocene sediments. Note the downdip presence of Teche deltaic deposits. Three major meander belts are illustrated and their approximate ages differ greatly (Teche = 5000 yrs. B.P.; Mississippi/LaFourche = 1500 yrs. B.P.; Atchafalaya = 800 yrs. B.P.). See Figure 1 for locations. Cross-sections constructed and modified from data obtained from Fisk (1952) and Krinitzsky and Smith (1969).


North
Simmesport
Atchafalaya River
Ramah
South
Morgan City
15
0m
-15
-30
0
20
40km
West
Bayou Teche
Atchafalaya River
East
Mississippi River
0m
-15
-30
0
20
40km
Channel-Fill/Levee
Backswamp
Lacustrine/Deltaic
Marsh/Teche Deltaics
Substratum (Gravel)
Pleistocene

occur directly above a substratum low, downdip near Bayou Teche (Fig. 30). Conditions for deposition of lacustrine and swamp environments alternated as alluviation continued, and these facies became more laterally continuous upward. It is important to note, that the lakes probably formed in a period of several hundred years (Smith et al., 1986) and deltas probably filled these lakes in less than 100 years. In spite of their significant thickness in the topstratum, the three to four lacustrine intervals account for only one-fifth to one-fourth of the geologic time represented by the topstratum.

Migration of the Atchafalaya River in the vicinity of Simmesport, has reworked swamp and lacustrine sediments into relatively coarser-grained meander-belt deposits (Fig. 30). Therefore, distributaries replace fine-grained deposits with channel, point bar, and overbank deposits. Downdip, the swamp and lacustrine facies of the Atchafalaya Basin grade into Teche deltaics and recent marshes (Fisk, 1952).

Preservation of the topstratum deposits (Fig. 3) is dependent on the depth to which they subside, and on the possibility of an upstream channel avulsion. Subsidence and/or a shift in the position of the river system is necessary to prevent scour and removal of the topstratum during low sea-level valley entrenchment. Topstratum deposits are also much more likely to be eroded in the updip part of the basin, and preferentially preserved downdip. Subsequent channel scour may completely remove the topstratum, or only the lowermost portion of the topstratum may be preserved. Fisk (1944; 1952) illustrated this scenario of vertically repeated topstratum and substratum units (Fig. 3).

Regional Occurrence of Cyclic Clastic Sequences

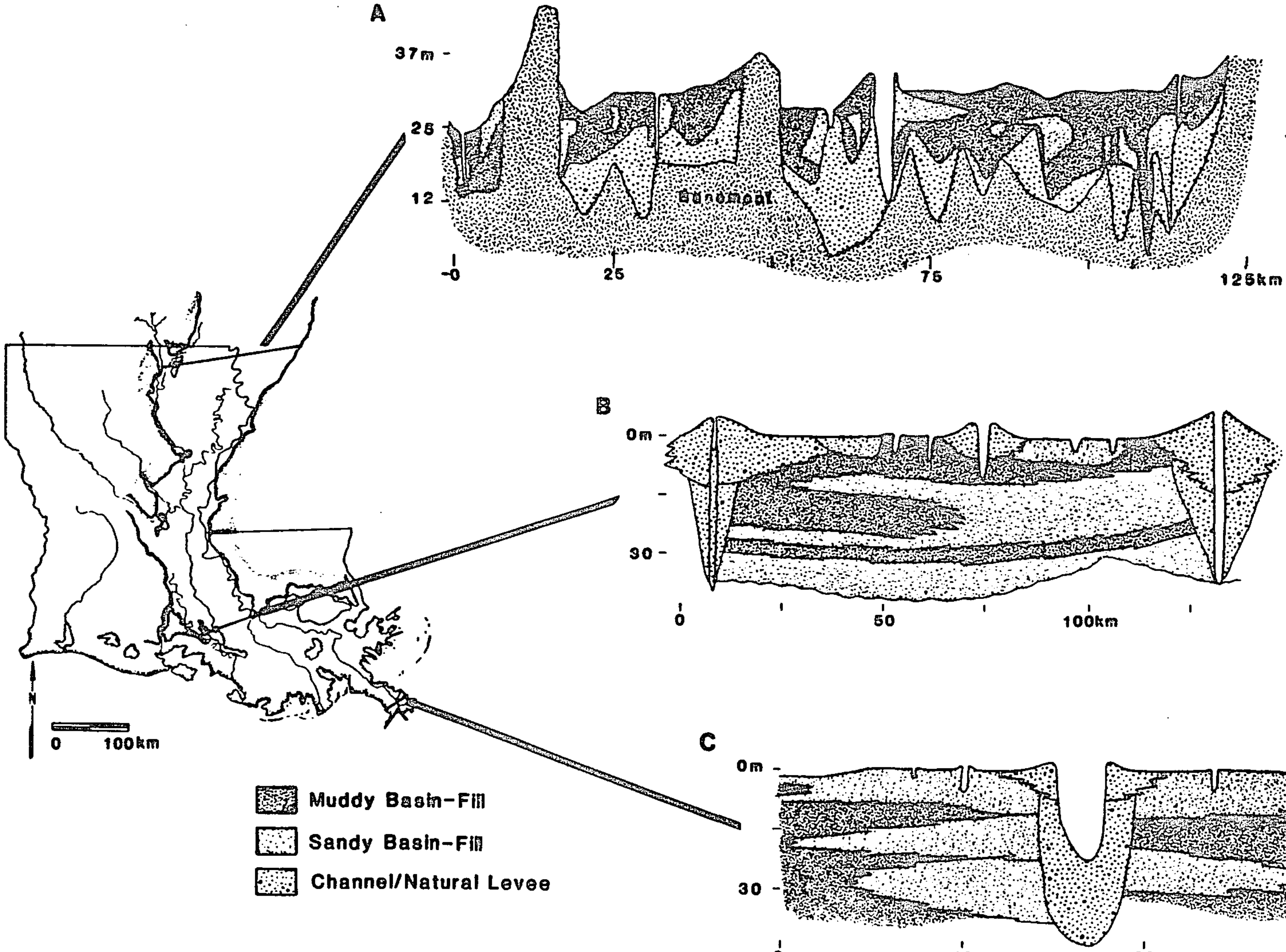
Topographically high meander belts in the upper alluvial valley decrease in elevation and divide into numerous distributary channels as they approach the delta plain. The topographic relief exhibited by the natural levees of fluvial channels and the adjacent backswamp or floodplain may be subtle, but it is significant enough that, during floods in excess of bankfull stage, large quantities of sediment will be transported overbank and deposited on the low-lying floodplain. Occasional meander belt avulsions occur in response to a favorable hydraulic head set up by the difference in topographic relief.

Floodplain aggradation through overbank deposition is a ubiquitous process in the alluvial valley and delta plain. A comparison of floodplain deposits along a traverse from the fluvial to transitional, and finally to the lower delta plain setting reveals their variability in sedimentary character and facies associations (Fig. 31). This variation is a function of: (1) fluvial processes; (2) floodplain or basin geomorphology; (3) the quantity and duration of depositional events; (4) subsidence; (5) sediment availability; and (6) marine influence. Each of these factors significantly influences sedimentary patterns and sequences, but the extent of their influence varies within the fluvial/deltaic system.

Regional facies associations, paleontology, and palynology can provide helpful information for paleogeographic reconstructions, but they require excessive amounts of data. Alternatively, information on the geometry and morphology (thickness and continuity) of floodplain deposits, in addition to vertical sequences, lithologies (sand/mud ratios), organic content, and the extent of soil formation can be readily acquired from core or outcrop data. As the floodplain deposits clearly reflect the processes of deposition, their interpretation will convey information on basin architecture (Miall, 1985) and relative position within the basin (fluvial, transitional, or delta plain setting).

Sedimentary structures, grain size, and sediment composition may be comparable among floodplain deposits from the alluvial valley to the delta front; however, a regional comparison of floodplain deposits reveals striking differences. Subsidence and fluvial geomorphology control the rate of formation and geometry of floodplain depressions which are eventually filled by overbank deposition. Sites of significant floodplain accumulation grade from oxbow lakes (sloughs) and levee depressions

Figure 31. Hypothetical cross-sections through the alluvial valley (A), transition zone (B), and delta plain (C). Floodplain deposits thicken and are sandier and less randomly distributed in a downdip direction. Modified from Fisk (1944) and Coleman and Gagliano (1964).


A
37m
25
12
Basement
0
25
75
125km
B
0m
30
0
50
100km
C
0m
30
0
10
20
30km
N
0
100km
Muddy Basin-Fill
Sandy Basin-Fill
Channel/Natural Levee

updip, to interdistributary basins in the transition zone, to marginal marine interdistributary bays in the lower delta. Channel interfluves broaden and lengthen downdip in conjunction with a decrease in levee height, therefore overbank deposition is a more continual process on the delta plain than in the alluvial valley, and sedimentary sequences thicken downdip (Fig. 31).

Overbank deposits will assume the geometry of the depression into which they are transported. On the alluvial plain, subsidence is relatively low and sheet-like splay or levee deposits are the most likely form of occurrence. Tabular overbank sand deposits are fed by a crevasse channel oriented at a high angle to the main channel. They are thin (approximately 2.4 m), and extremely discontinuous (Fisk, 1944). Depositional events are episodic and of short duration. Oxbow or slough fillings may be sandy (chute cutoff) or muddy (neck cutoff) and assume the form of the channel (Fisk, 1944). Vertical sequences are more likely to fine upward than coarsen upward.

Soil formation is an important process on the floodplain, thus initial depositional contacts may be sharp. Later, vegetation will destroy sedimentary structures and blur lithologic contacts. Soil development will leach grains, thereby increasing the clay content, and organic material will be oxidized.

Increased subsidence in the transition zone and lower delta plain enhances the formation of interdistributary lakes and bays, and also affects the manner in which facies are stacked vertically (Bridge and Leeder, 1979; Fielding, 1984). In comparision to the fluvial setting, the arrangement of facies in the floodplain downdip of the alluvial valley (transition zone and delta plain), implies better organization of the progressive sedimentary events. Lakes and bays are filled by prograding clastic deposits which display coarsening-upward sequences of variable thickness. Crevasse splays in the lower delta are greater in aerial extent and thickness than the lacustrine deltas, partly due to deposition in an unconfined bay and greater subsidence rates.

Orientation of the lake delta/crevasse splay deposits relative to the source channel is usually at an acute angle. Crevasse channels which diverge from the trunk stream at high angles are inefficient and close rapidly (Russell, 1936). This relationship imparts a dip-oriented sedimentary "grain" to the geomorphology of the transition zone and delta plain. This "grain" is strongest in the transition zone where interdistributary basins modify sedimentary patterns, and are alluviated by lake deltas.

Detailed subsurface data illustrating the facies relationships of crevasse splays in the lower delta are lacking. High subsidence, the variable depth of interdistributary bays, and the increased density contrast between riverine and marine waters should result in stratigraphic differences from the freshwater lacustrine deltas. Geomorphically, the crevasse splays in the lower delta display an unconfined, almost radial morphology due to multiple channel bifurcations and the deposition of lobate distributary mouth bars. It is quite likely that channel and distributary mouth bar sediments comprise the bulk of one of these splays.

As subsidence is high and flood events are frequent in the lower delta, the splays are vertically stacked as coarsening-upward deposits (Coleman and Gagliano, 1964). Wells et al. (1984) summarized the growth rates of the major Mississippi subdeltas (splays) and found that they reach maximum development in an average of 68 years, approximately the same amount of time required to fill Grand Lake with deltaic sediments. The thickness discrepencies between one representative depositional cycle from the fluvial, transition, and lower deltaic settings (2.3 m at Vicksburg; 5.0 m in Grand Lake; 10 m in the lower delta; Fisk, 1944; Coleman and Gagliano, 1964) are related to greater subsidence and sedimentation rates. Therefore, isochrons diverge rapidly downdip, then converge towards the deep basin.

Soil profiles, which define sedimentary cycles, are more poorly developed in the lower delta than in the transition zone, although rooted intervals are present and mark the upper boundary of a bay-fill sequence. In addition, detrital and <u>in situ</u> organic accumulation is greater in the fresh to brackish transition zone.

Fluvial to delta plain facies transitions, similar to those described for the Mississippi, illustrate the occurrence, geometry, and associations of channel, floodplain, and deltaic deposits in ancient nonmarine/deltaic depositional settings (Ayers and Kaiser, 1984; Fielding, 1984; 1986; Flores, 1981; Schafer and Sneh, 1983; Sevon, 1985). In studies of the Carboniferous fluvial to deltaic sequences in the Appalachian Region (Ferm and Horne, 1978), facies representing a gradation from nonmarine to marine depositional conditions are well-preserved.

Ferm and Cavaroc (1978) noted that the Allegheny Formation of West Virginia represents a middle Pennsylvanian alluvial valley which grades northward into Pennsylvania through transition and delta plain settings. Fluvial sandstones pass laterally into backswamp shales. En echelon, linear sandstone bodies indicate subsidence and meander belt avulsion and occur with coarsening-upward (lake-filling) sandstone deposits in the alluvial valley and transition zone (Ferm, 1978; Ferm and Cavaroc, 1978). Thin stray sandstones in the backswamp shales were emplaced by flood events (Baganz et al., 1978). A similar stratigraphic sequence is presently forming in the Atchafalaya Basin. Subsidence will cause the Teche, Mississippi, and Atchafalaya meander belts to be offset vertically, with lake deltas forming sandy connections in between (Fig. 30).

Downdip, the sandstones thin and decrease in occurrence, whereas backswamp shales thicken and grade into interdistributary bay shales in the delta plain. Sharp-based crevasse splays frequently filled these bays, and the sharp base became gradational in the distal portion of the splay as the sand and bay shale interfingered. Seatrocks associated with coals, reflect the intensity of soil formation in the basin (Ferm and Cavaroc, 1978), and should be best developed in the alluvial valley and degrade downdip.

CONCLUSIONS

Meander belt/delta lobe switching by the Holocene Mississippi Delta creates interdistributary basins which are dip-elongate, areally extensive lowlands isolated between two meander belt ridges and occupy the transition zone from fluvial to marine deltaic environments. Upon development of a new distributary channel within the interdistributary basin, large volumes of terrigeneous clastic sediment are introduced into the basin, most of which are deposited in numerous prograding lacustrine deltas. Basin alluviation through lake delta deposition is a prerequisite to the deposition of a marine delta in the Gulf of Mexico.

In the case of the Atchafalaya Basin in south-central Louisiana, the Atchafalaya River, a major Mississippi distributary, has filled a large network of shallow, interconnected lakes through delta progradation. These deltas are thin (3 to 5 m), but cover areas greater than 100 km^2. One such delta, the Lake Fausse Pointe delta, was artificially abandoned shortly after its formation, but provides an excellent setting in which to study the geomorphic and sedimentologic character of one lacustrine delta. An historical analysis of the Lake Fausse Pointe delta indicates that the 29km^2 coarsening-upward deltaic wedge was deposited in approximately twelve years.

A relatively long quiescent period of low sedimentation in the lake preceded formation of the delta, and resulted in the deposition of a thin layer of bioturbated sandy to silty clay over a rooted paleo-backswamp surface. Deltaic sediments are dominantly represented by laminated and burrowed prodelta silty clay, grading upward into rippled and cross-bedded silty sand and sand in the delta front and distributary mouth bar. Sediment texture coarsens upward, simultaneous with a decrease in biogenic structures. Density-induced underflows inferred from the delta stratigraphy and the presence of sharp-based, normally graded sediment packages in the delta front and distributary mouth bar, had a strong influence on sediment transport and distribution patterns. However, the relief on the lake bottom was a major factor controlling delta morphology. Delta aggradation was accomplished through sediment accumulation on the distributary mouth bar, and overbank deposition, which built natural levees along the distributary channels.

Lakes in the Atchafalaya Basin have been filled by fluvial processes in less than 100 years. Lake delta-building is a rapid process, but the lake delta is essentially abandoned once it is bypassed by the parent stream. A subsequent relative increase in basin subsidence results from decreased sedimentation on the delta. This sediment deficit enhances backswamp development on the delta, and ultimately results in its transgression and burial. Portions of abandoned deltas may be reworked by fluvial processes, however most of the sequence is preserved as laterallly continuous, coarsening-upward deposits encased in backswamp clay. Three to four cycles of lake delta deposition and abandonment are evident in the topstratum of the Atchafalaya Basin.

The sedimentologic and stratigraphic nature of floodplain deposits varies from the alluvial valley through the transition zone to the delta plain. Sandy floodplain deposits of significant thickness and extent may be formed by overbank deposition, channel development, or avulsion. The muddy floodplain expands and thickens downdip of the alluvial valley with an accompanying increase in the occurrence and size of lakes, sloughs, and bays; sites conducive to overbank deposition. Therefore, lake deltas and crevasse splays become more common, thicken, and increase in area from the transition zone to the delta plain. A major downdip change occurs through the decrease of fluvial channel sand and a concomitant increase in floodplain mud with multiple sandy interbeds.

Greater subsidence in the delta plain results in stacking of channels, deltas, and crevasse splays, thus significantly thickening the time-equivalent sedimentary sequences in the delta plain relative to the same interval in the alluvial valley. Examples of similar stratigraphic relationships preserved in ancient clastic fluvial/deltaic sequences are present in the Paleozoic of Europe and North America.

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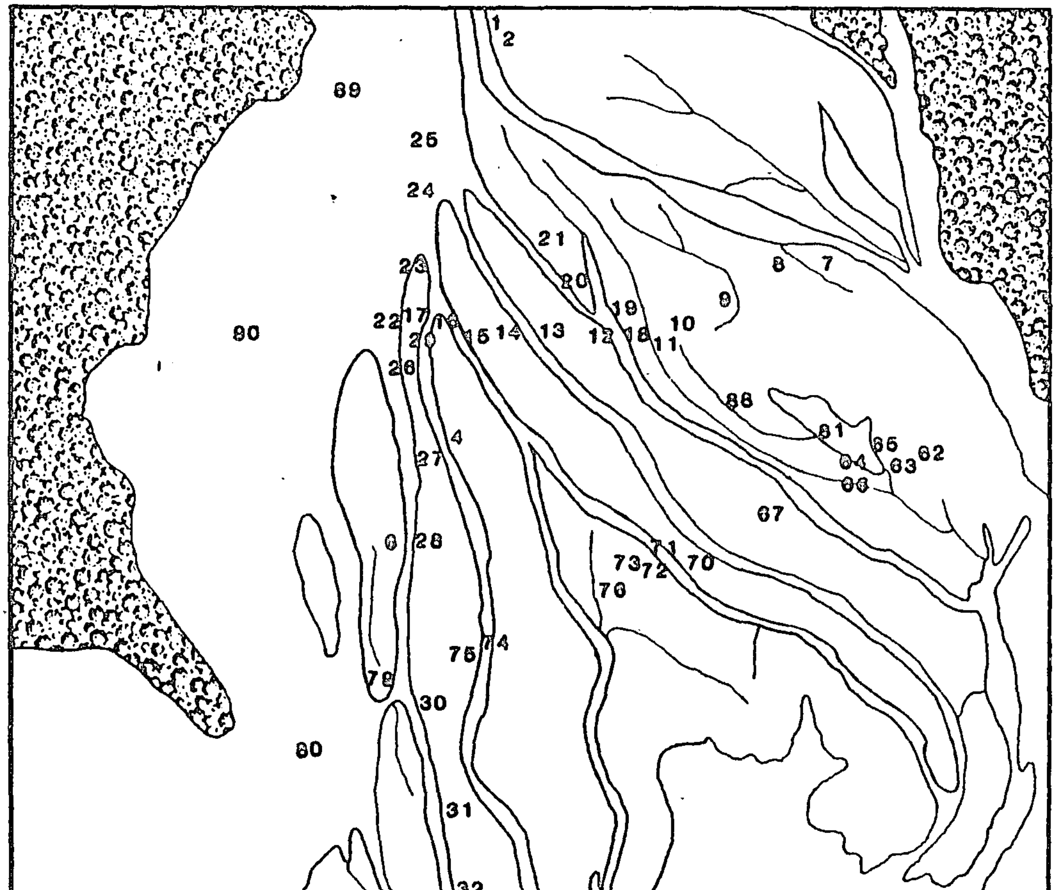
APPENDIX

Graphic representations and sedimentary descriptions for selected cores used in the Lake Fausse Pointe study. Cores were described in the manner outlined by Boyles et al. (1986). A legend of symbols used to represent sedimentary features and a location map are included for reference.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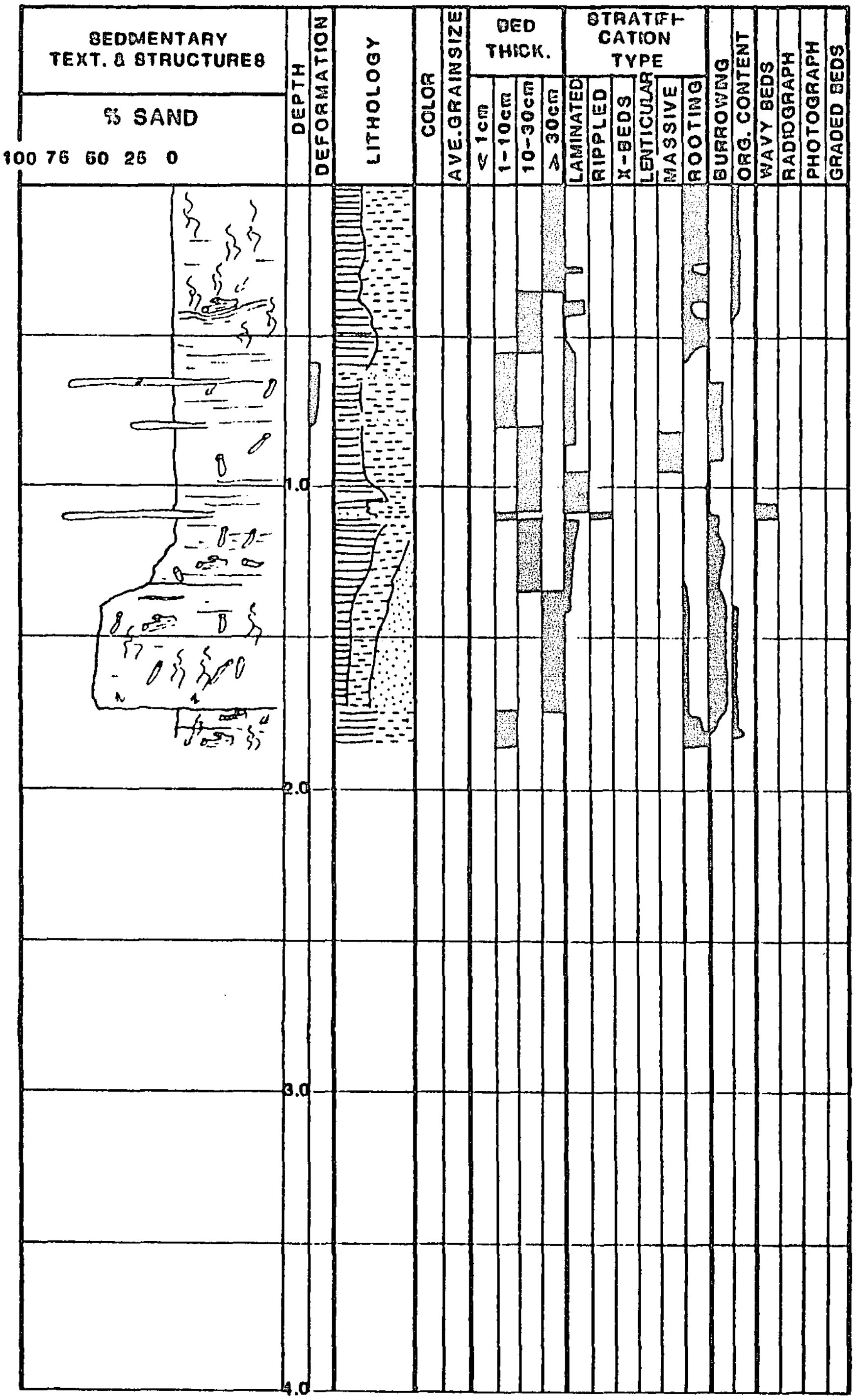
Current Ripples
Wave Ripples
Cross-Laminations
Laminations
Wavy Beds
Lenticular Beds
Soft-Sediment Deformation
Faults, Slumps
Rip-Up Clasts
Mud Balls
Mudcracks
Rooting
Burrows
Logs, Organic Debris
Carbonate Concretions
Iron Oxide Concretions
Bivalves
Gastropods

CORE NUMBER FP-1 CORE DEPTH (M) 1.83

LOCATION LAKE FAUSSE POINTE



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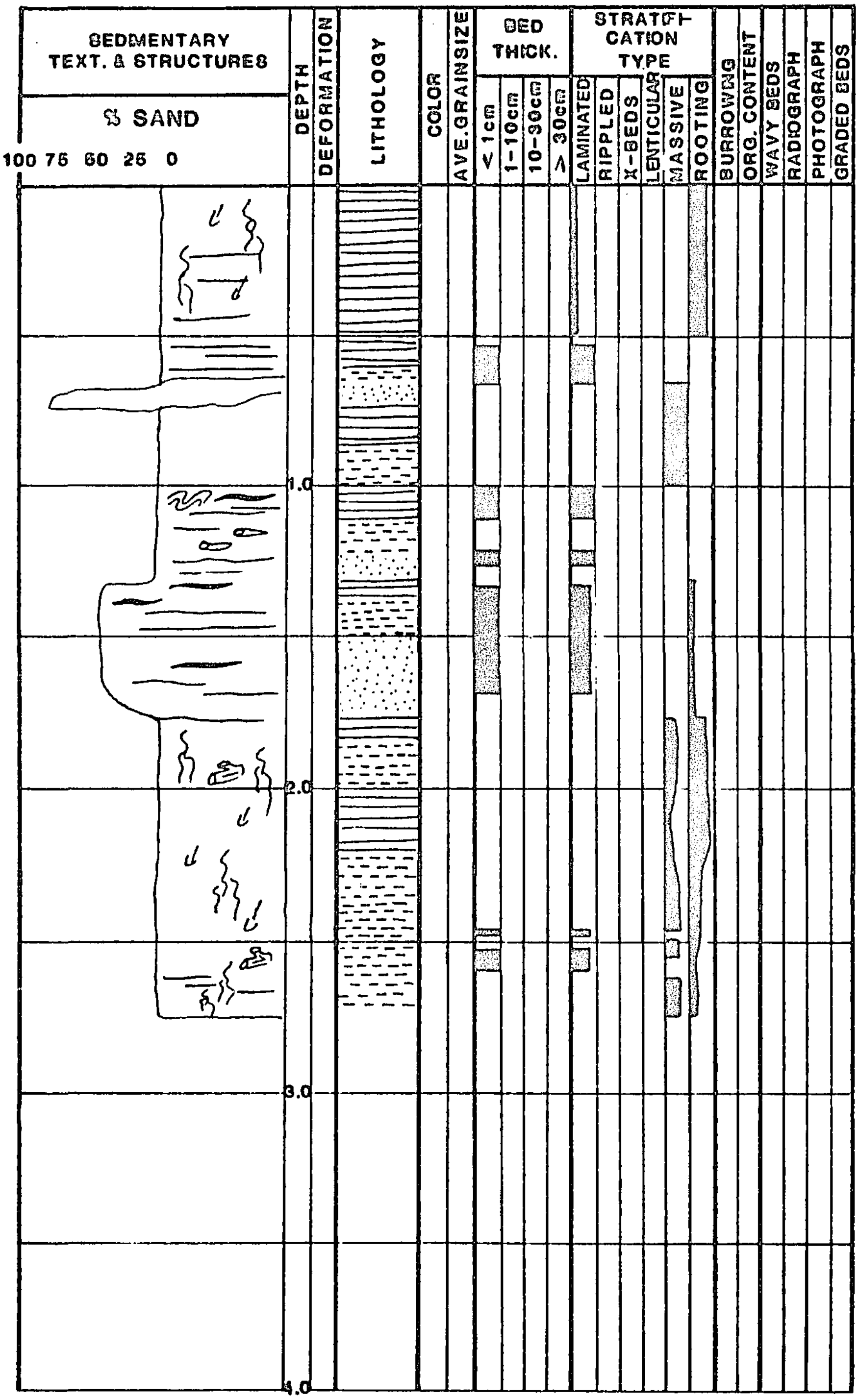
LOCATION LAKE FAUSSE POINTE



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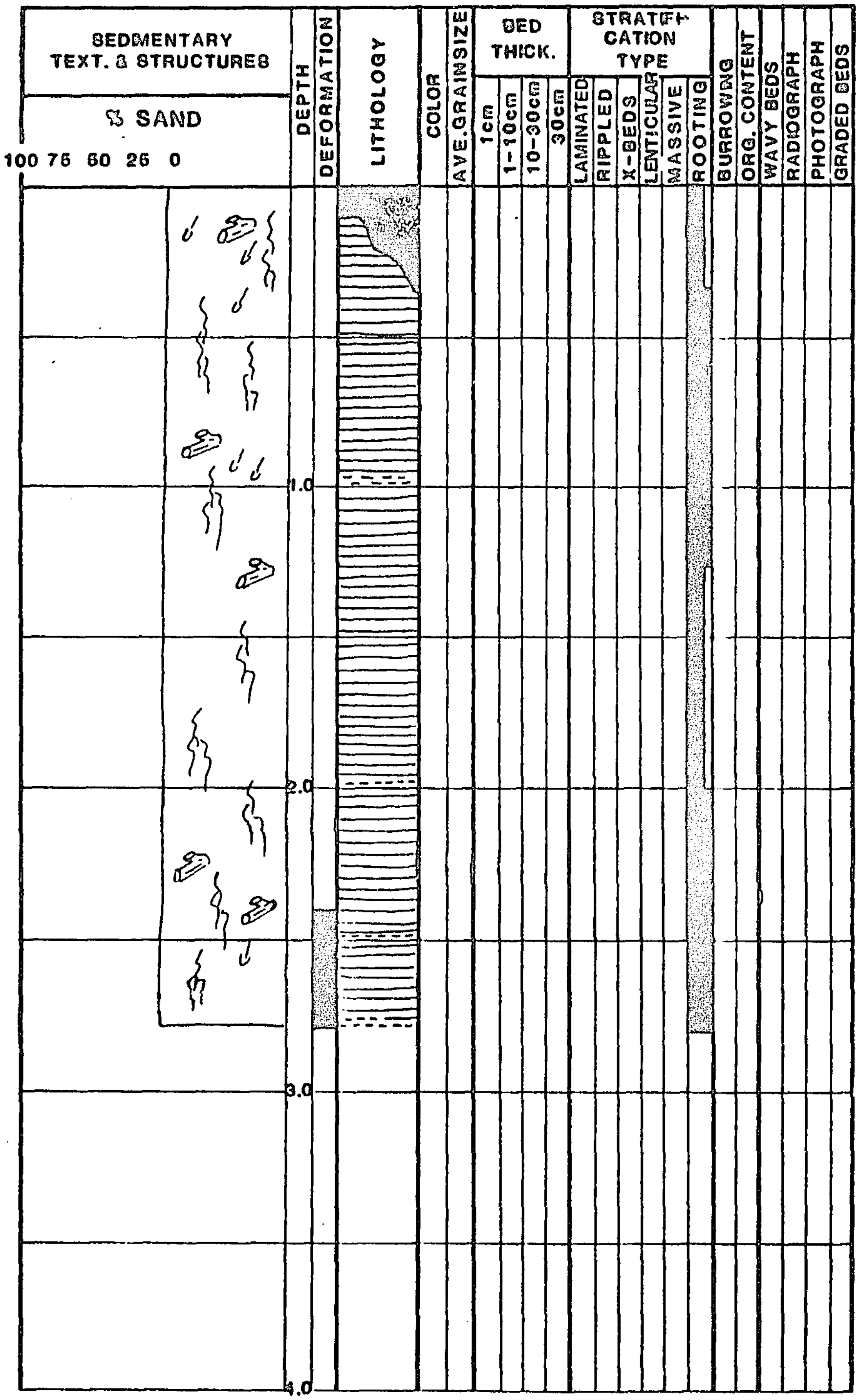
LOCATION LAKE FAUSSE POINTE



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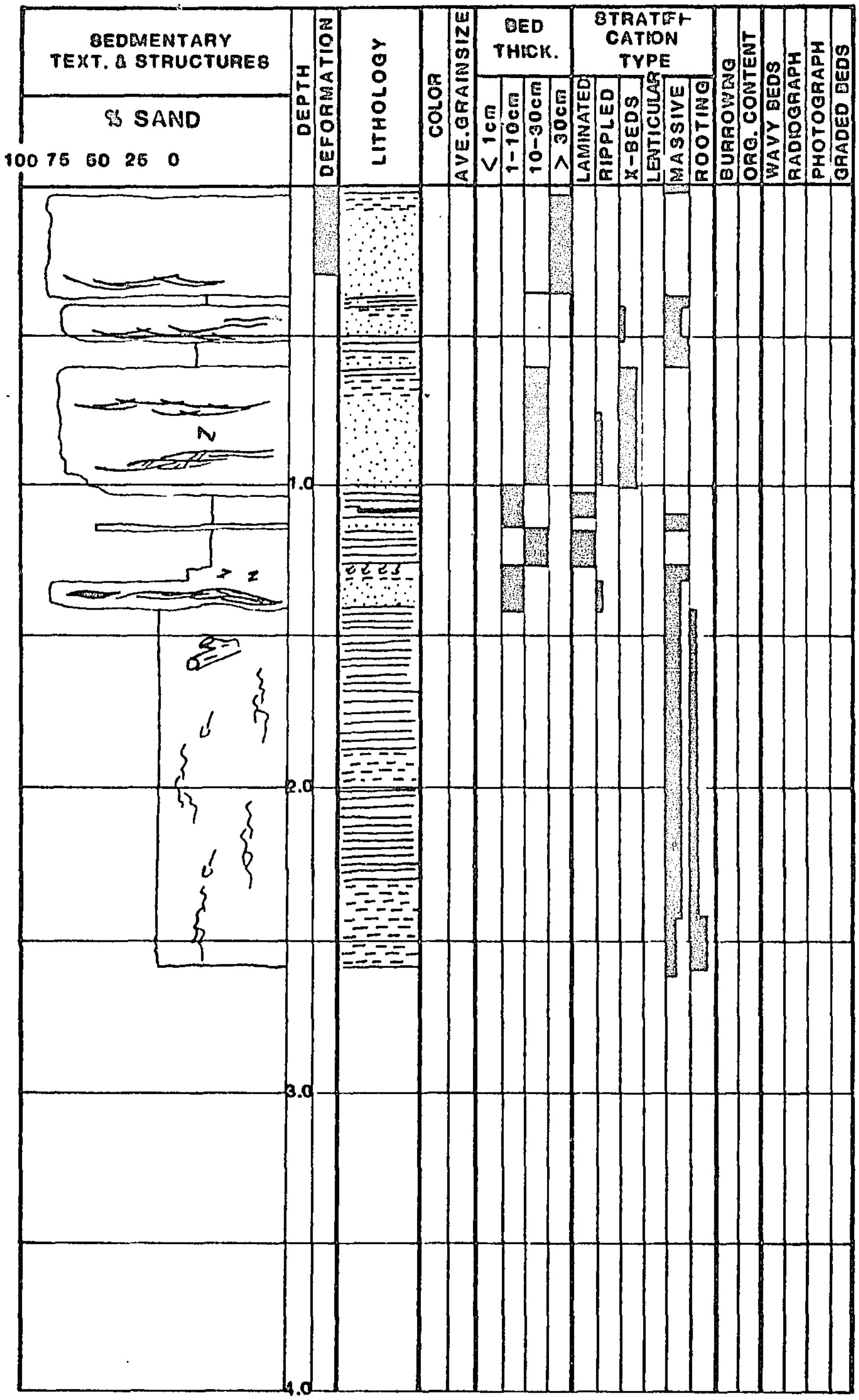

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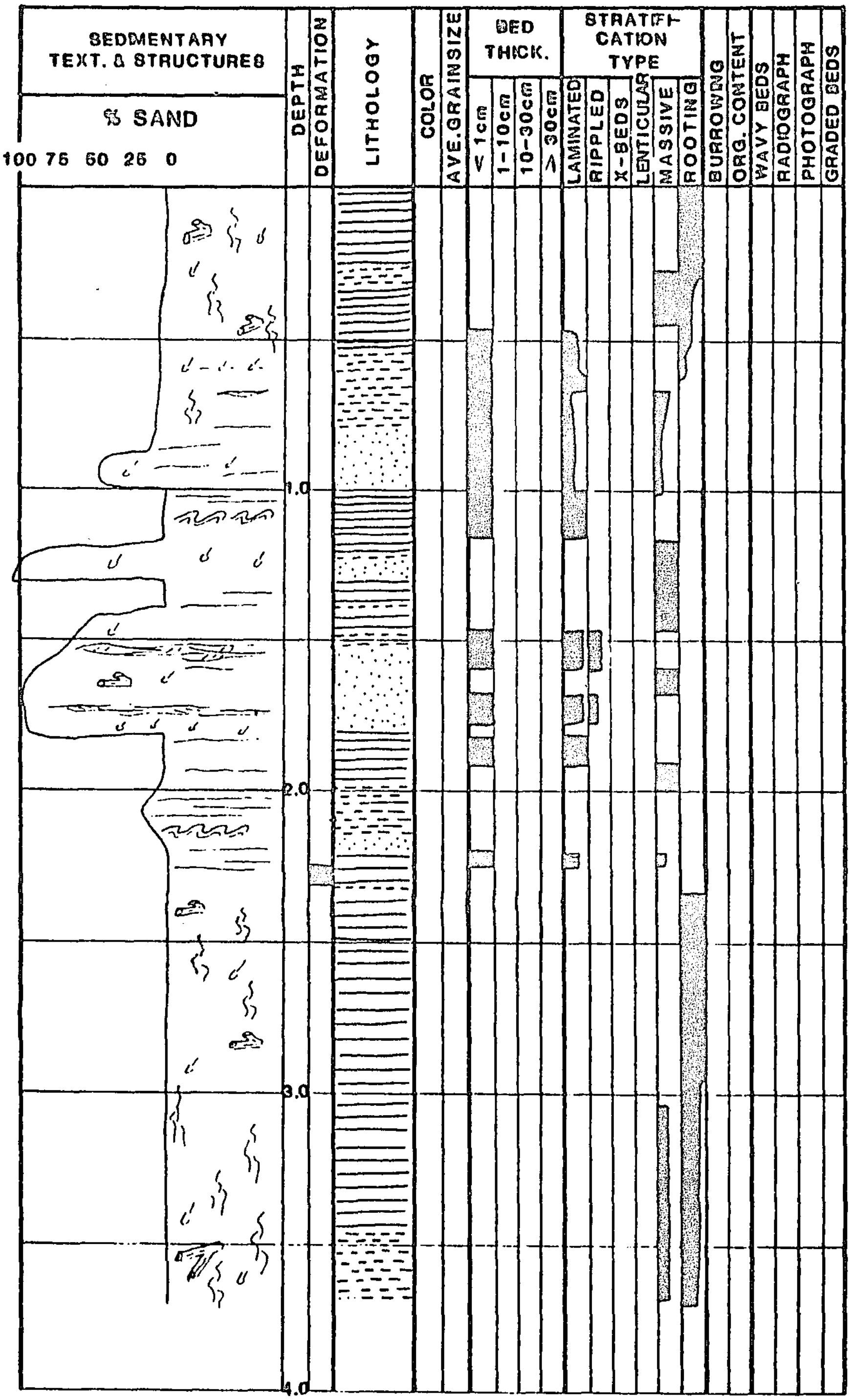

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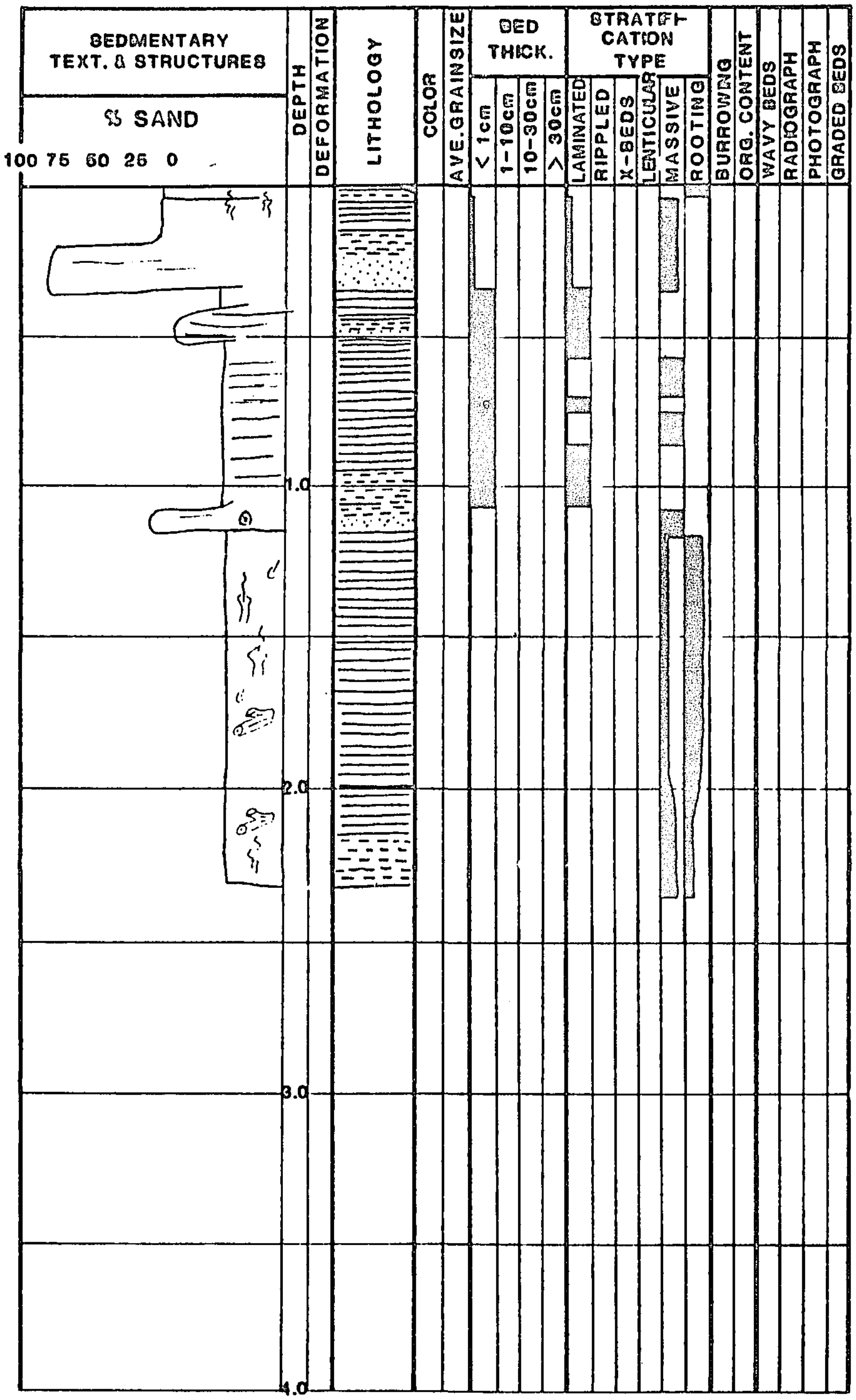
LOCATION LAKE FAUSSE POINTE



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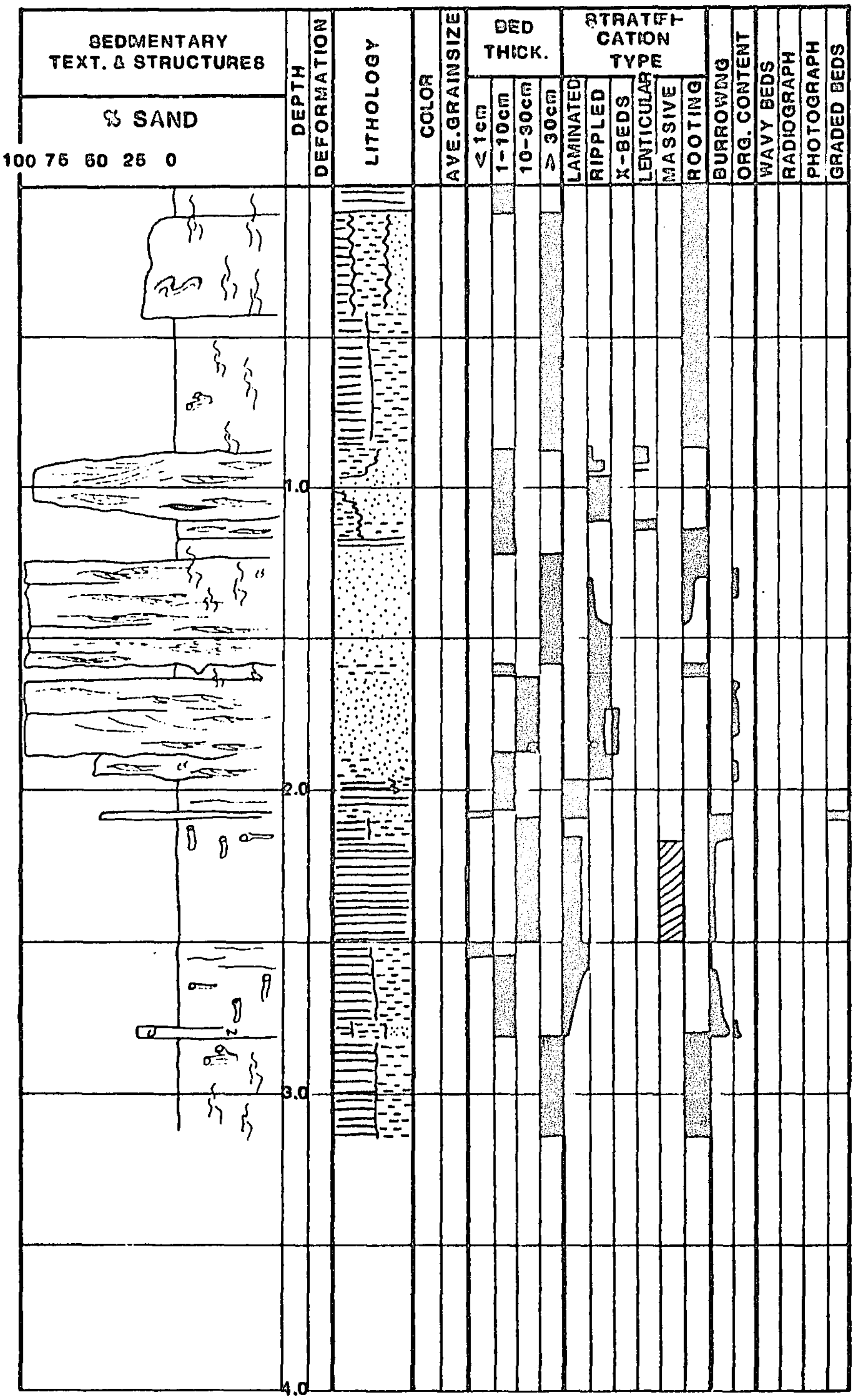

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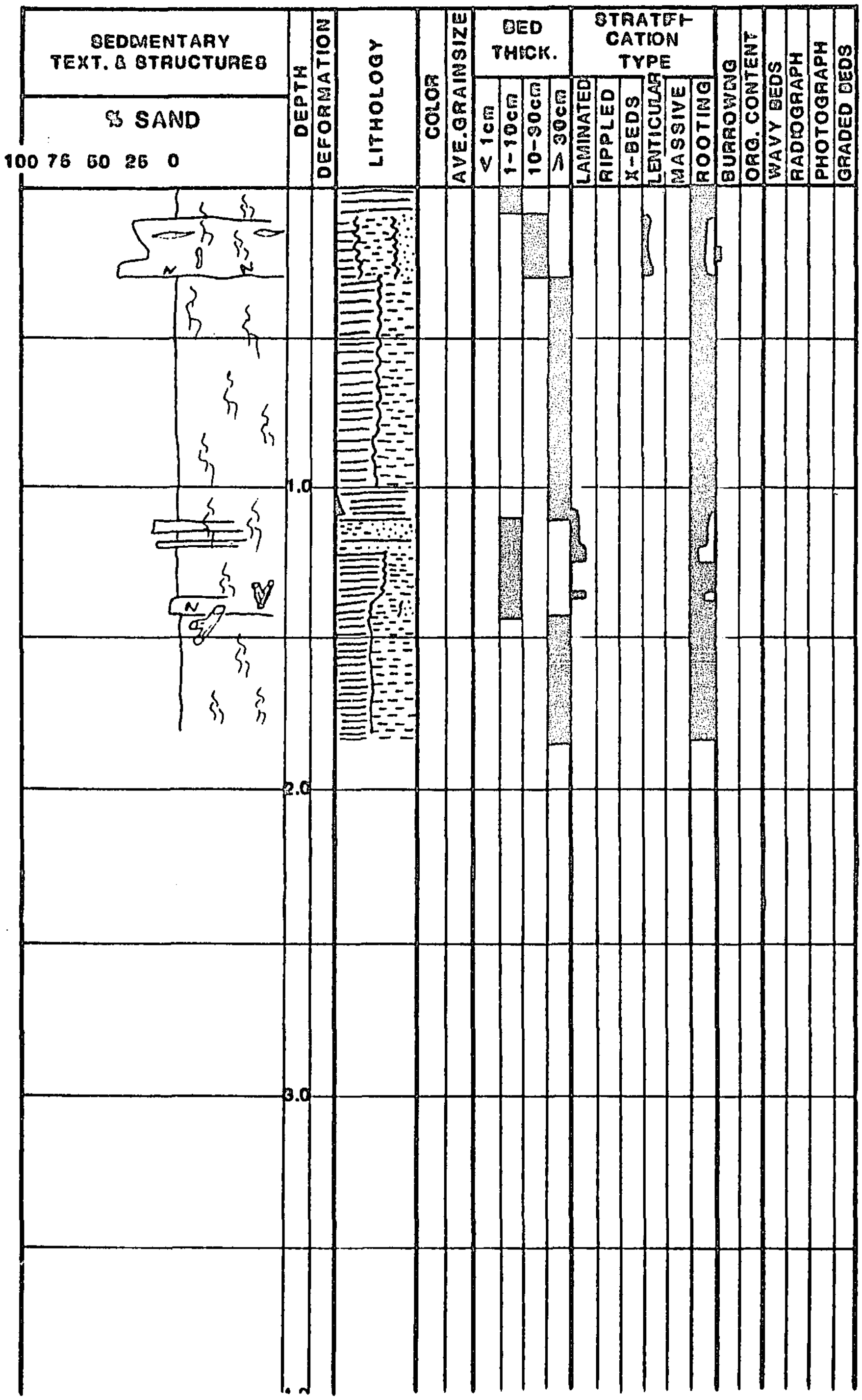

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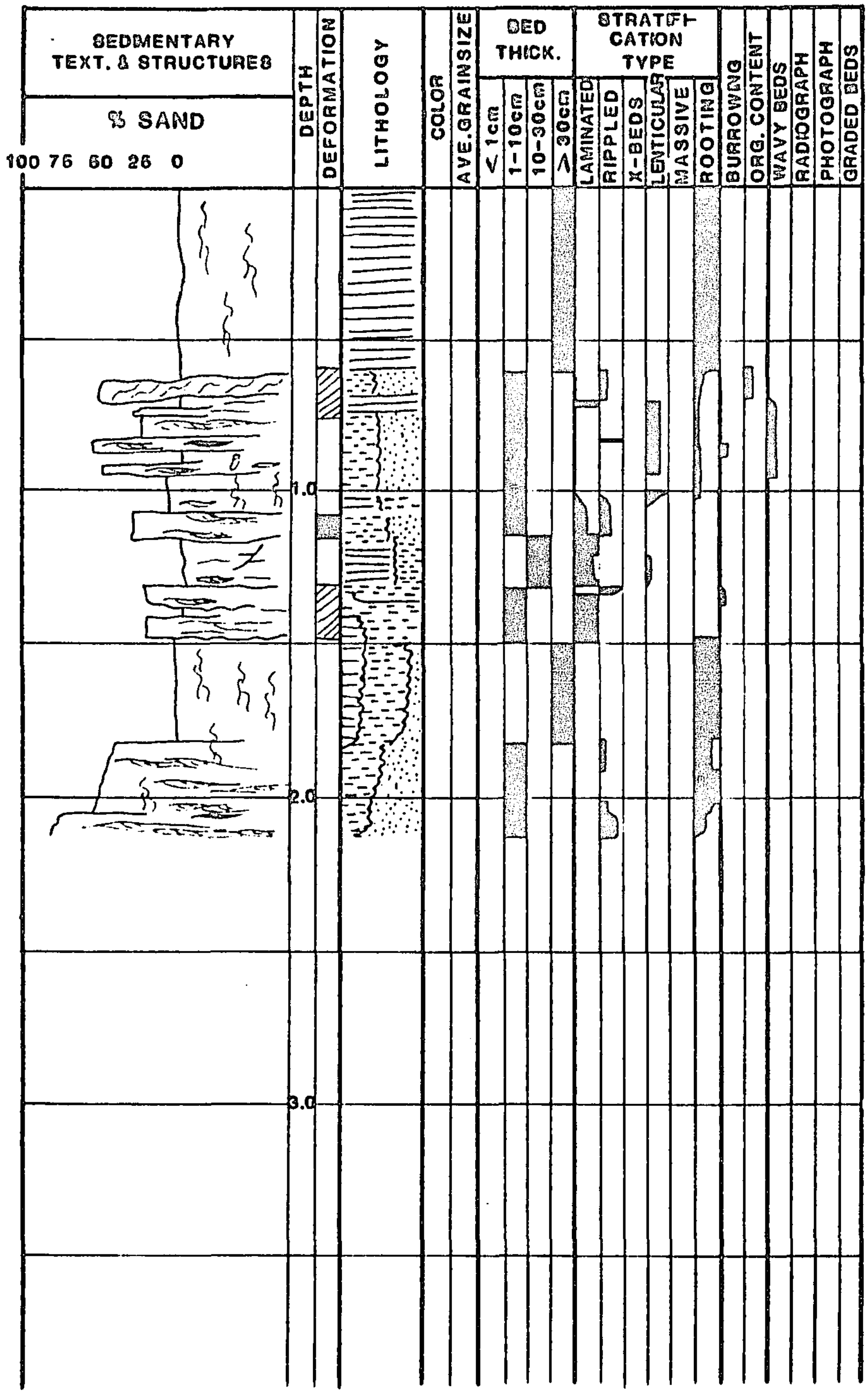

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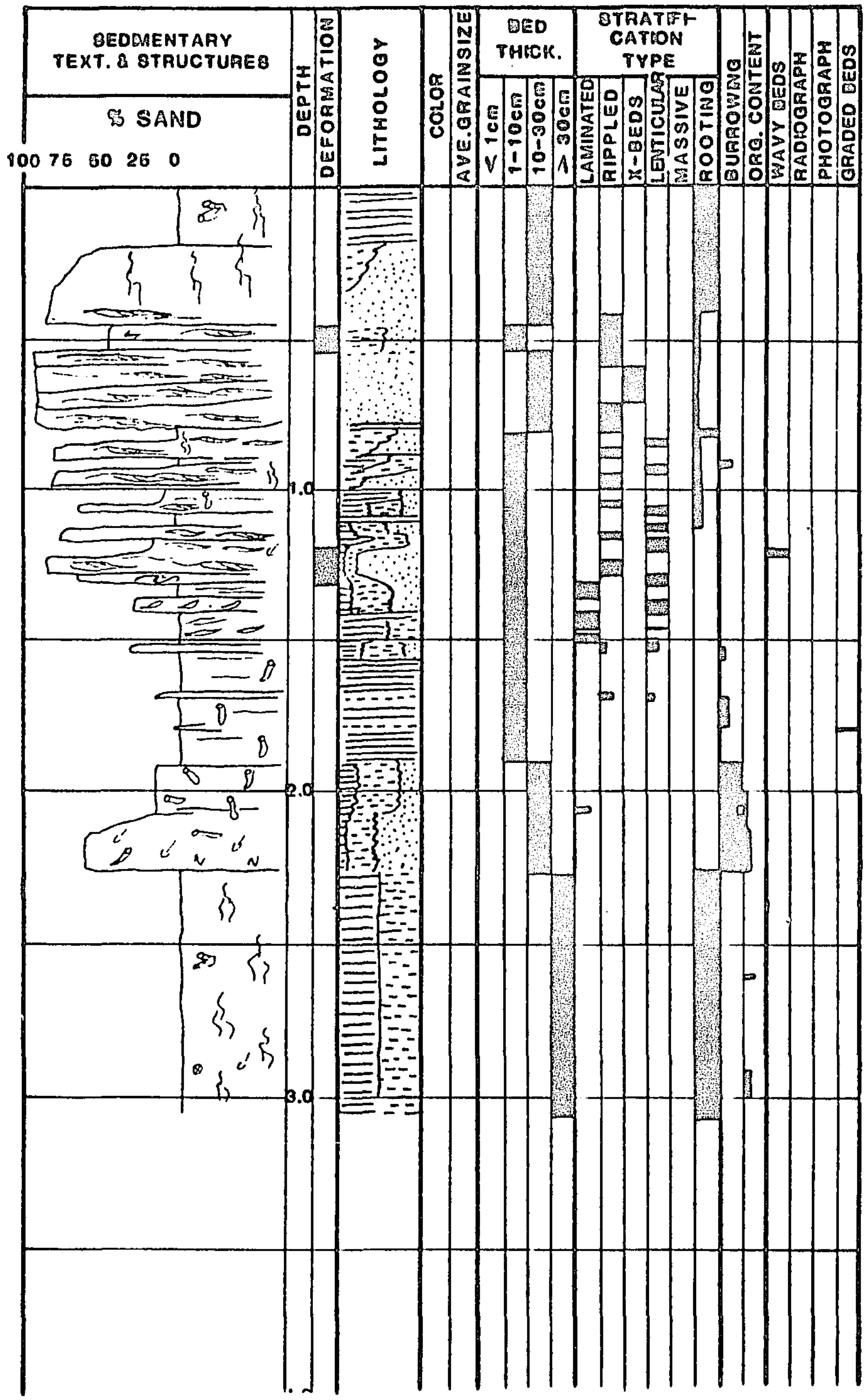

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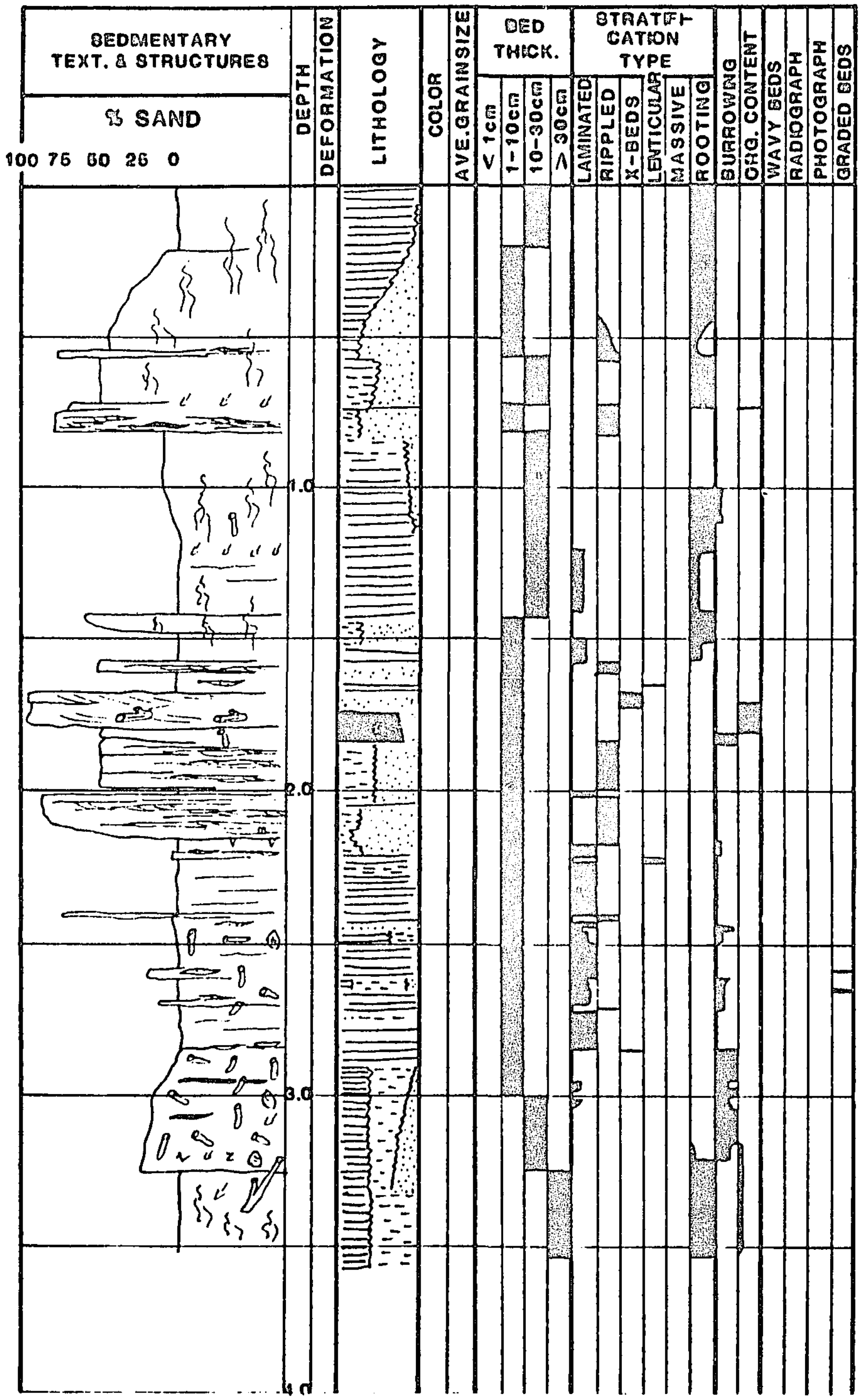

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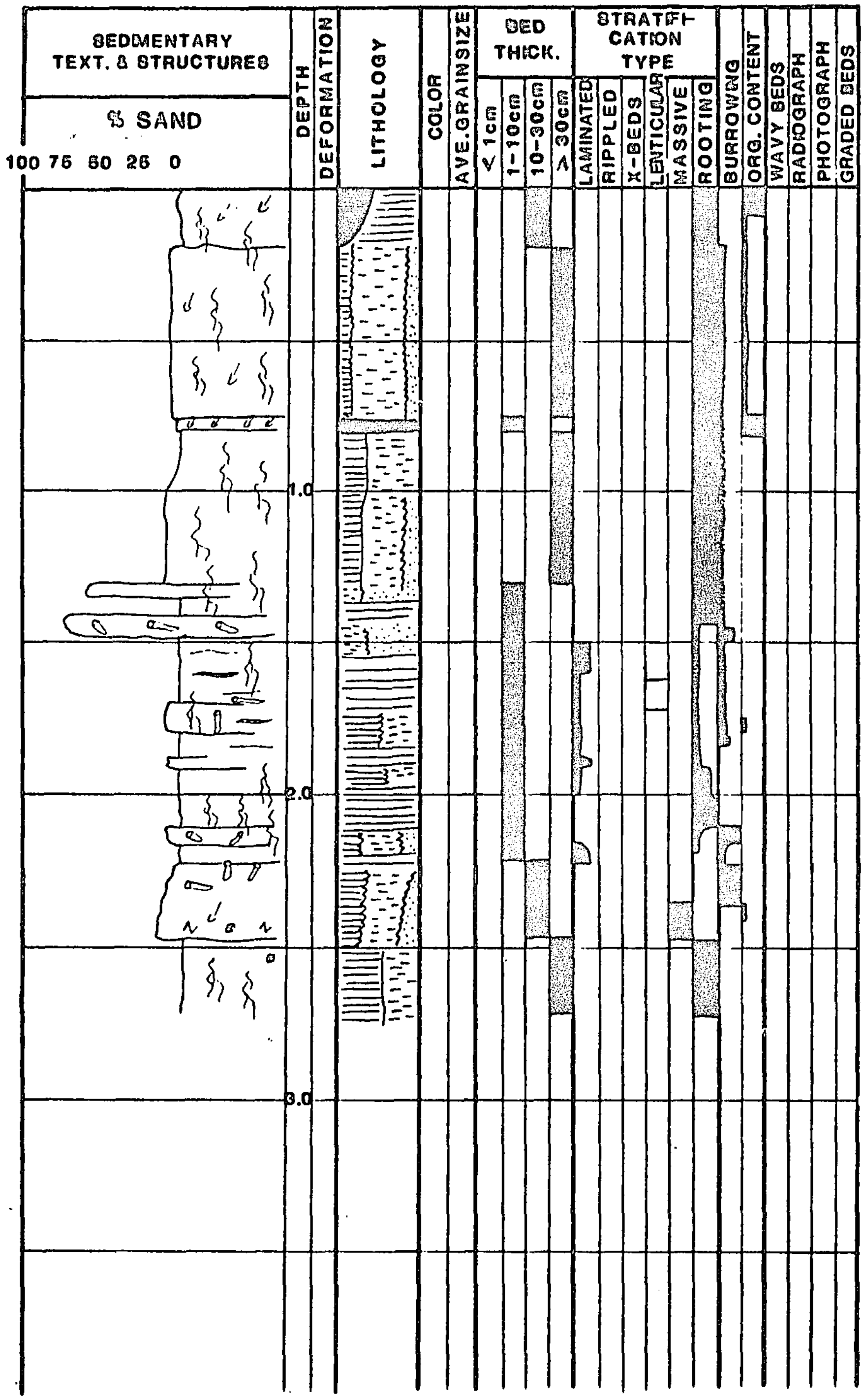
LOCATION LAKE FAUSSE POINTE



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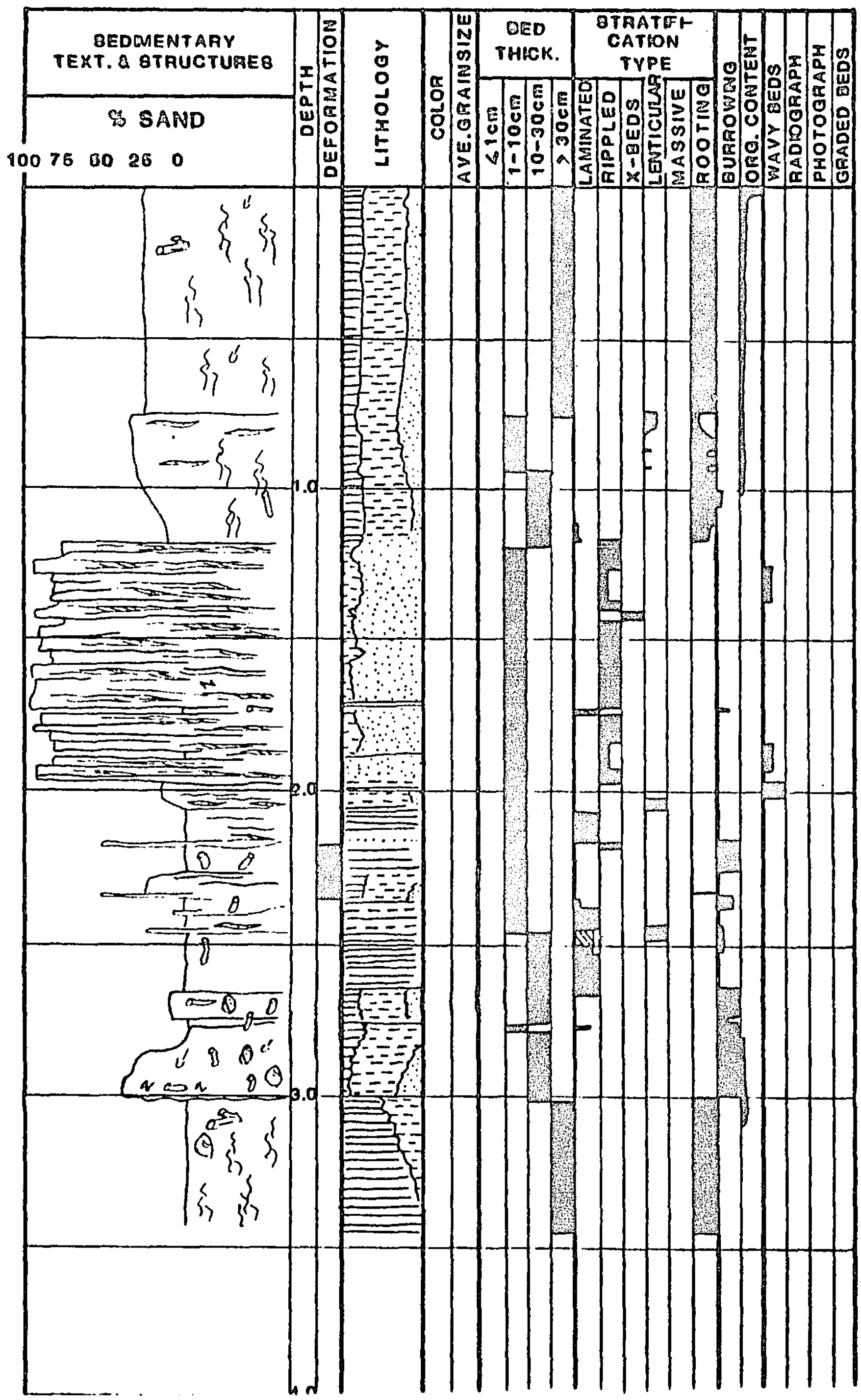
LOCATION LAKE FAUSSE POINTE



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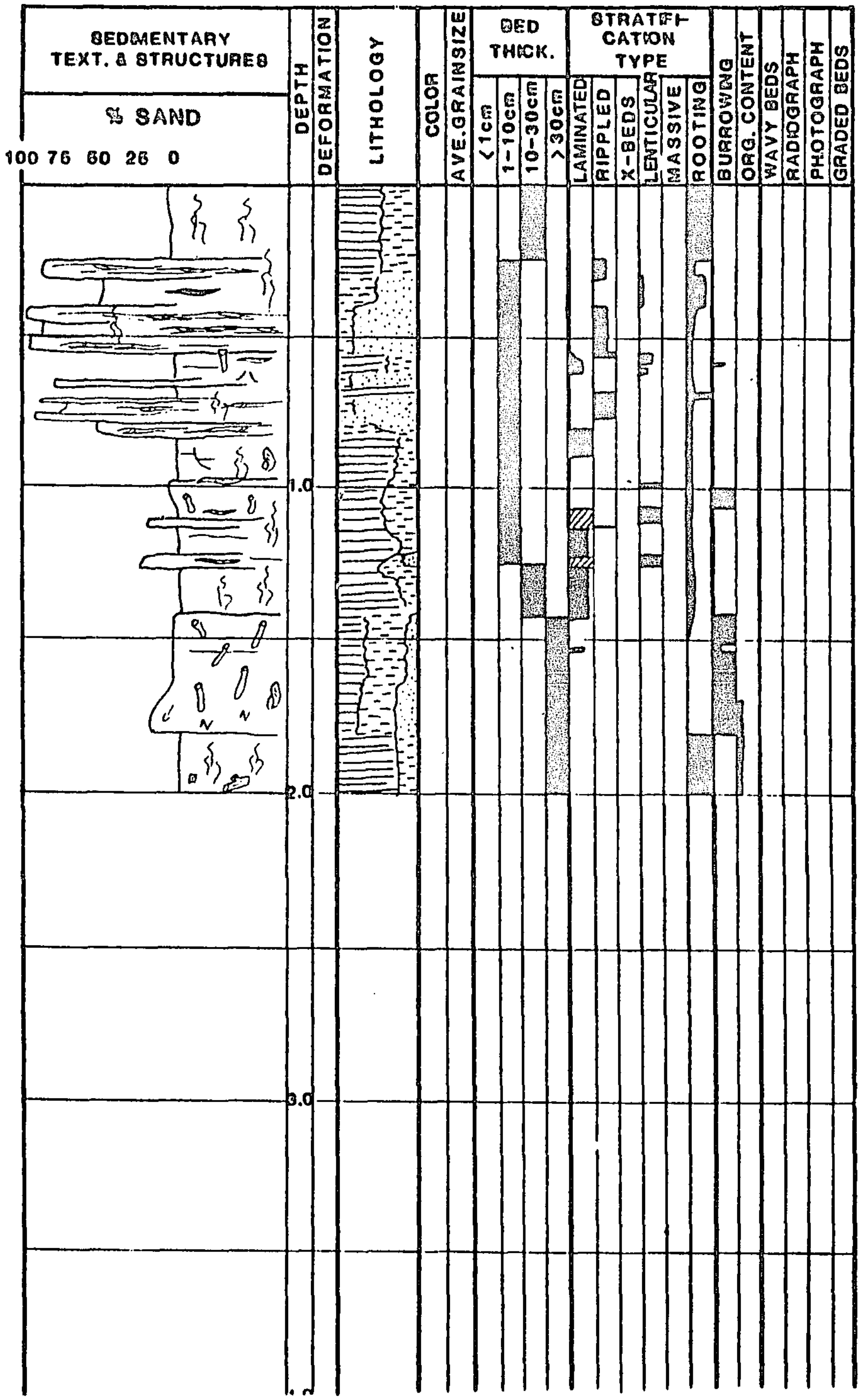

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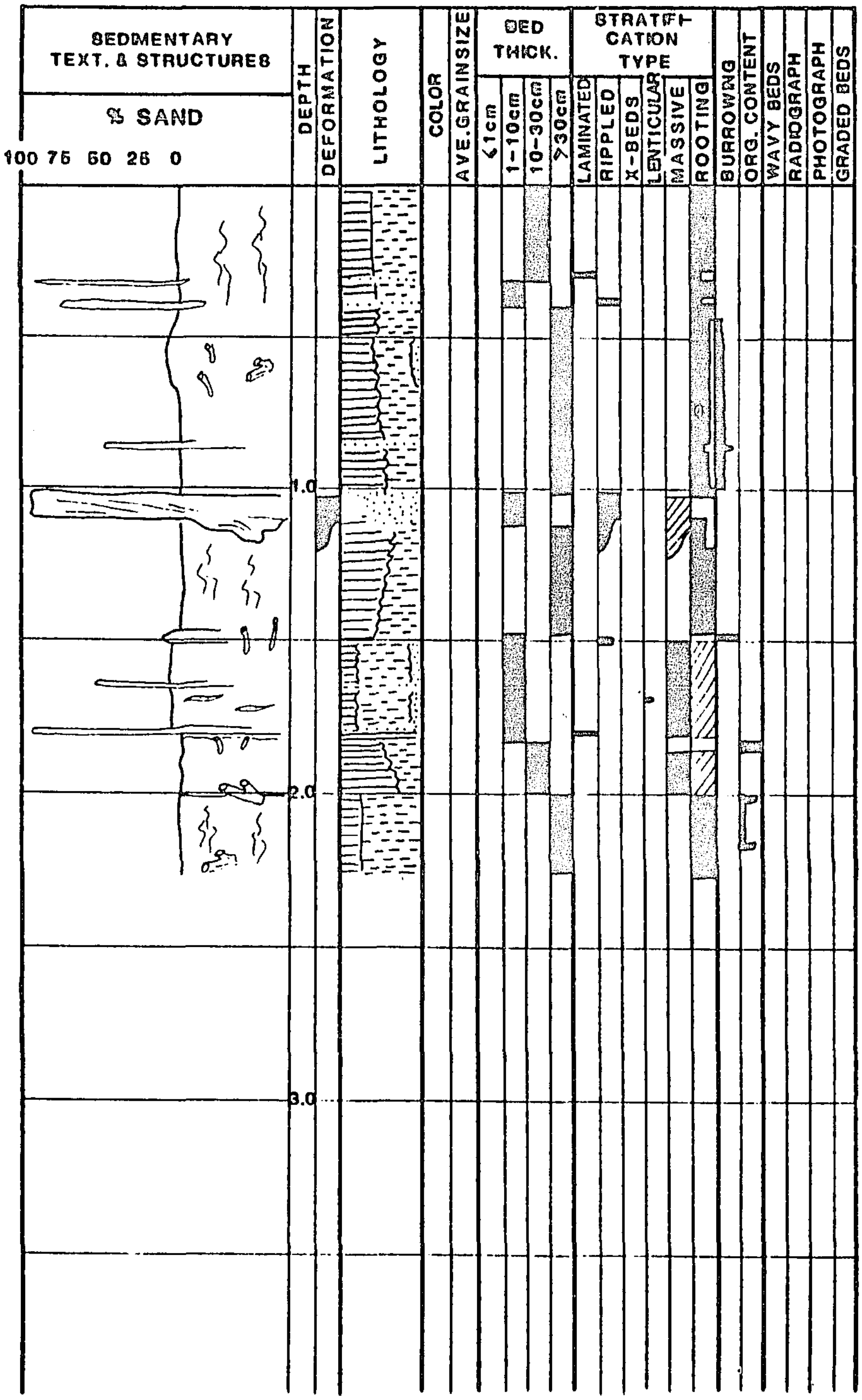
LOCATION LAKE FAUSSE POINTE



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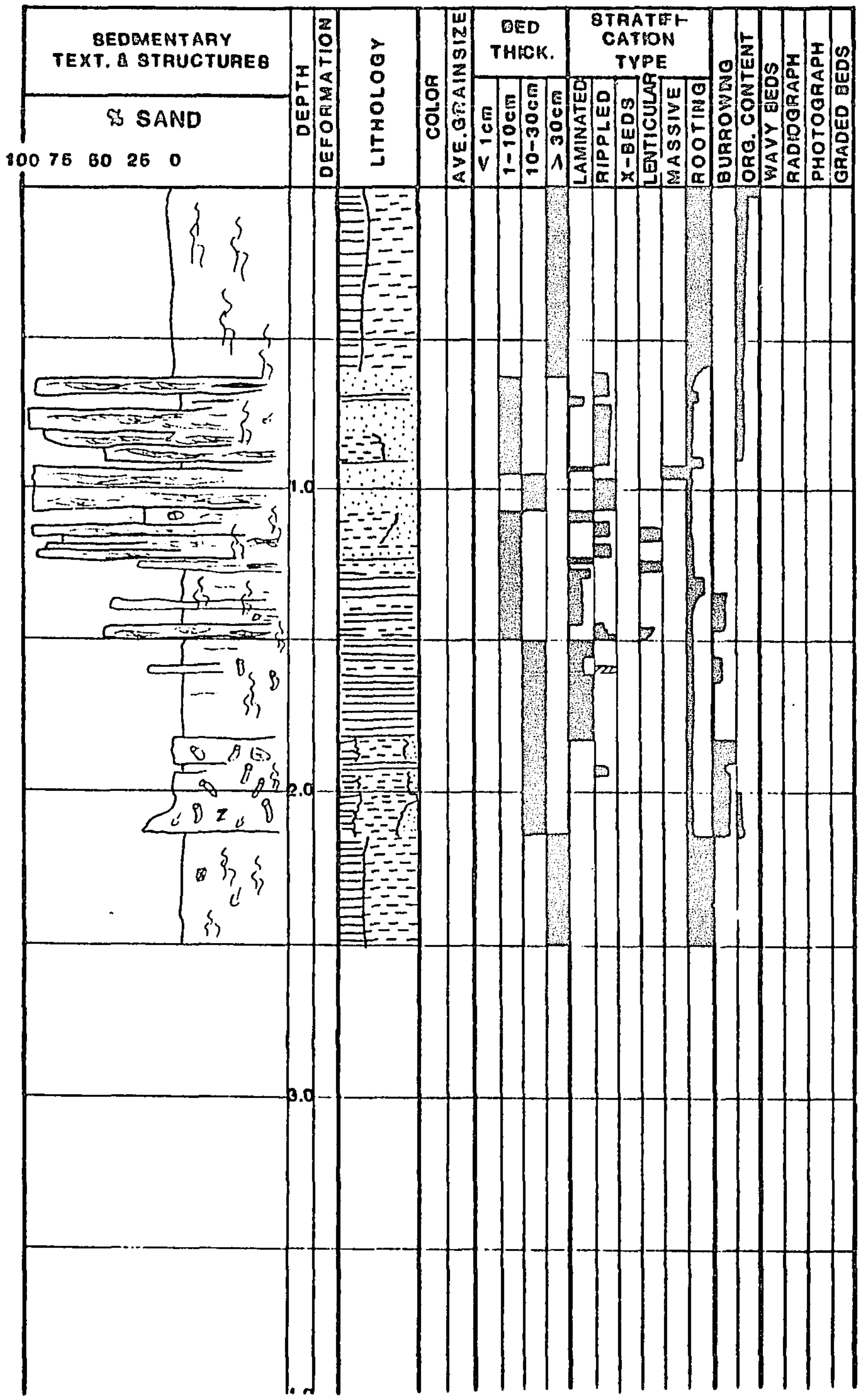

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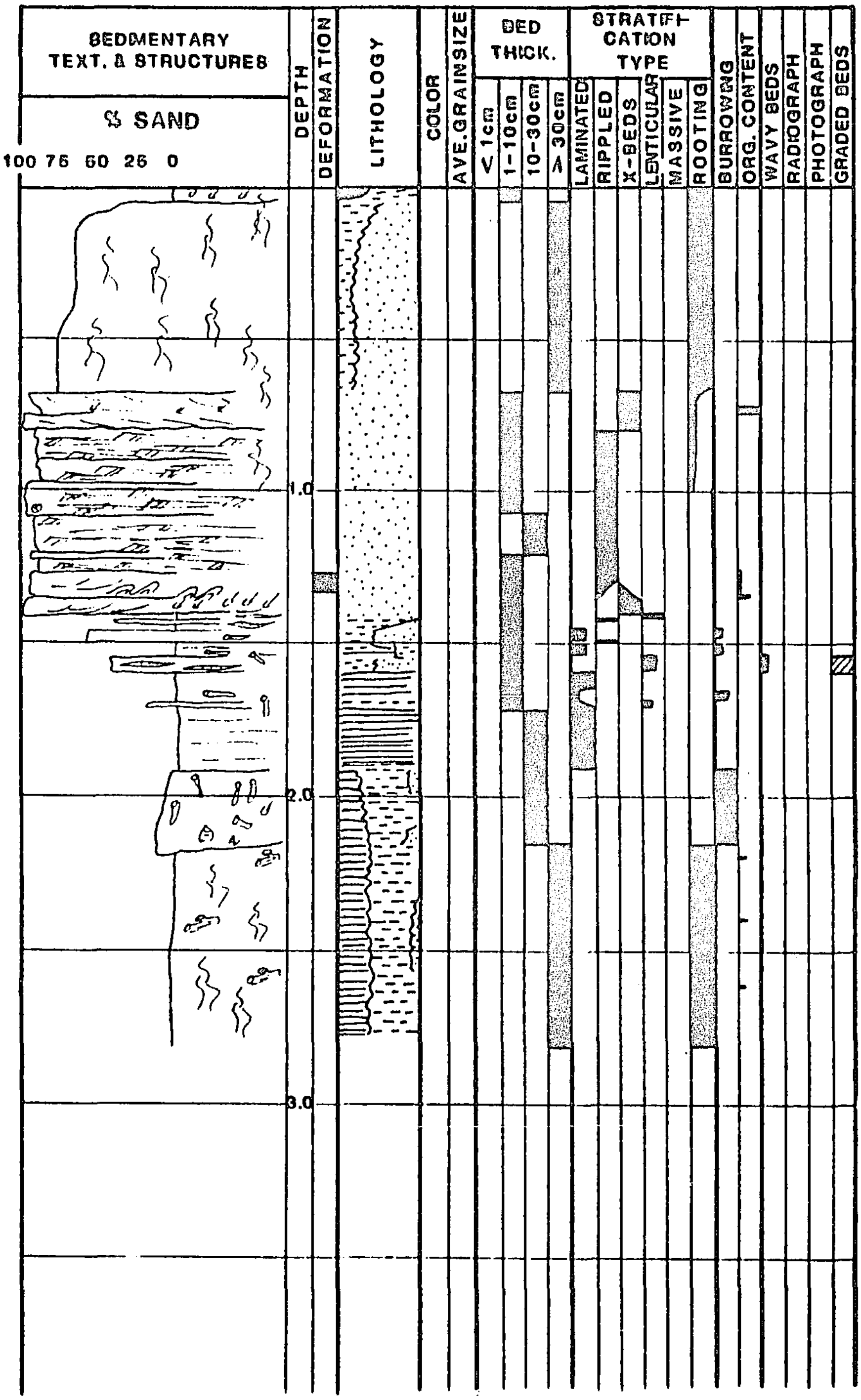

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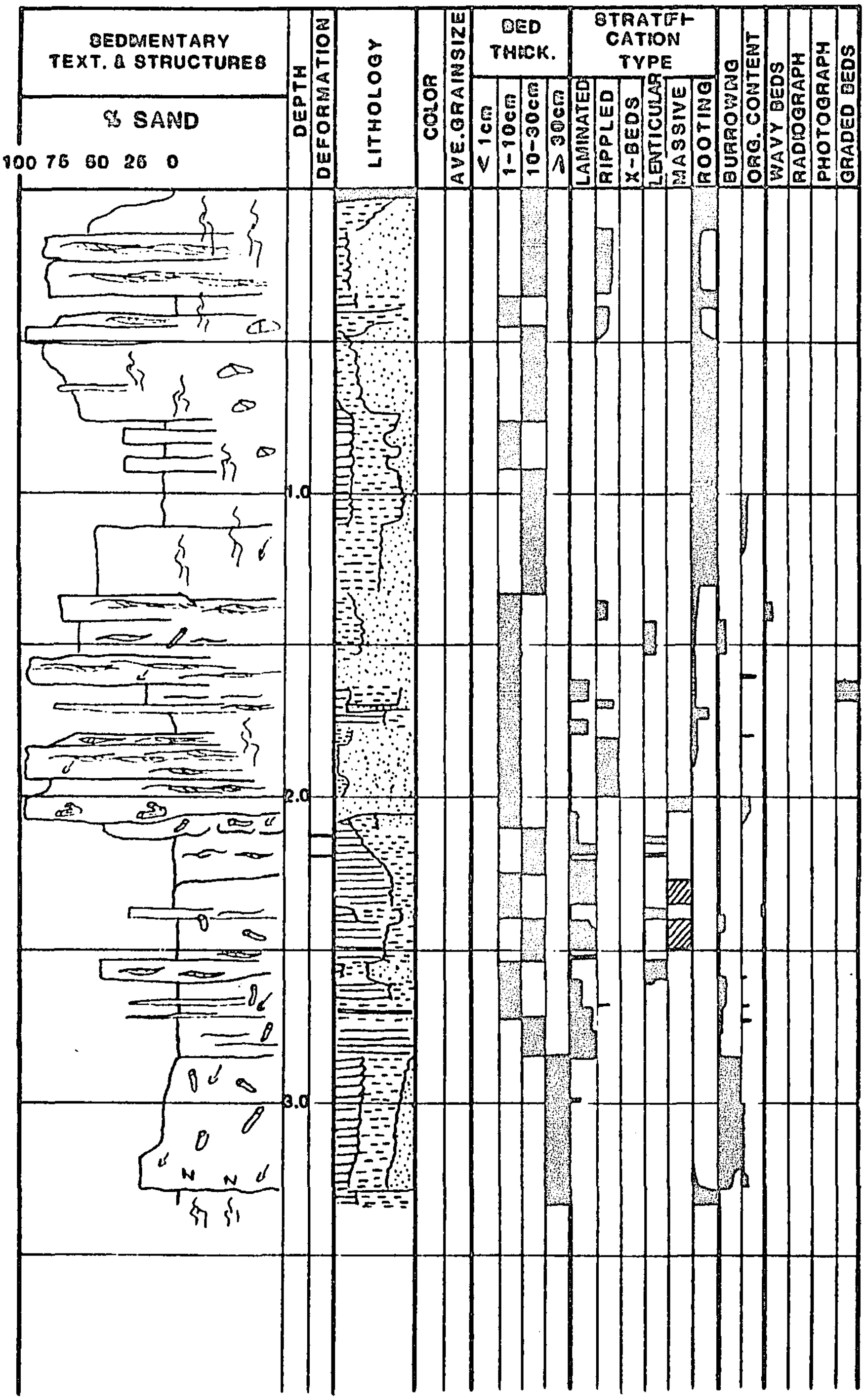

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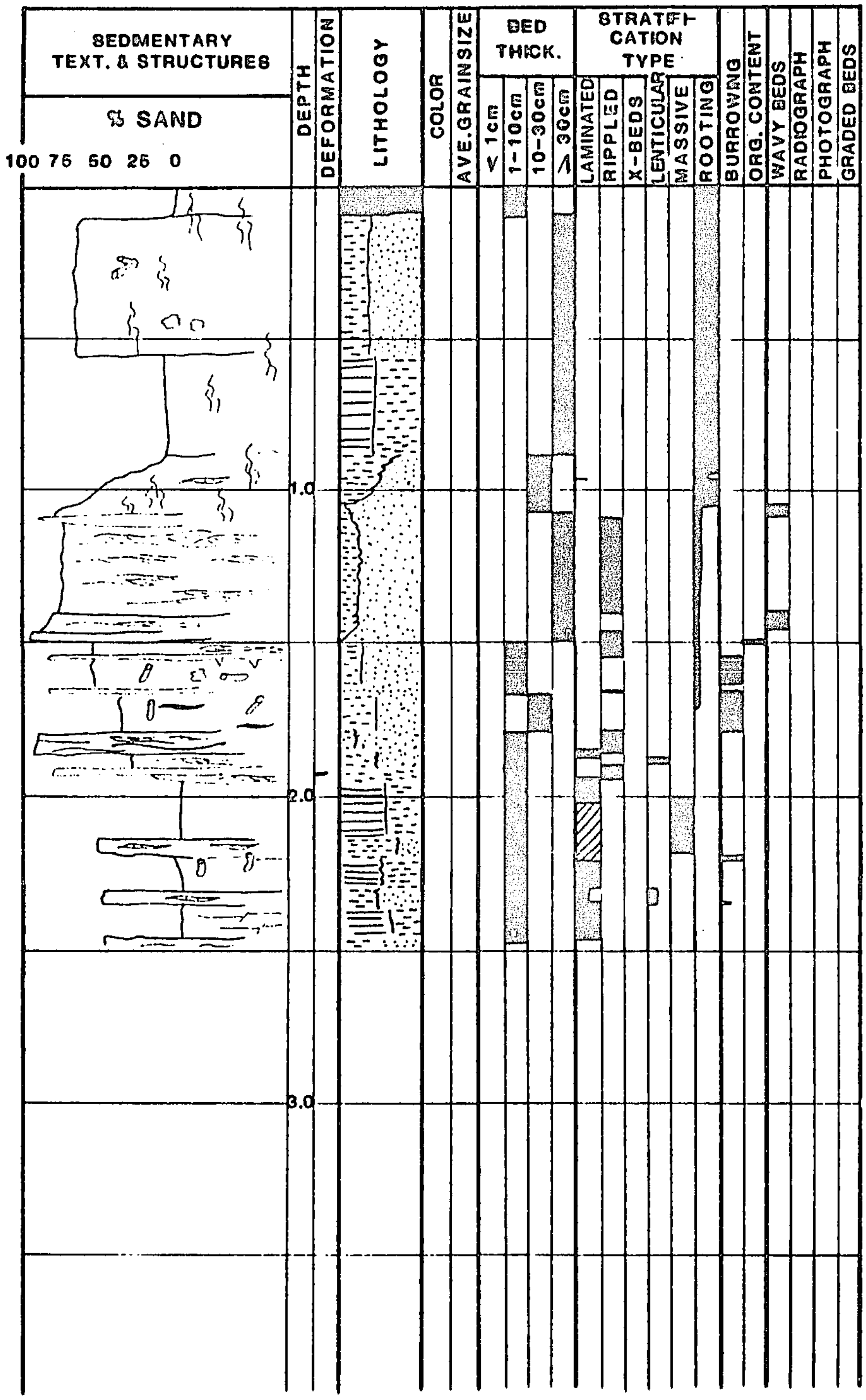

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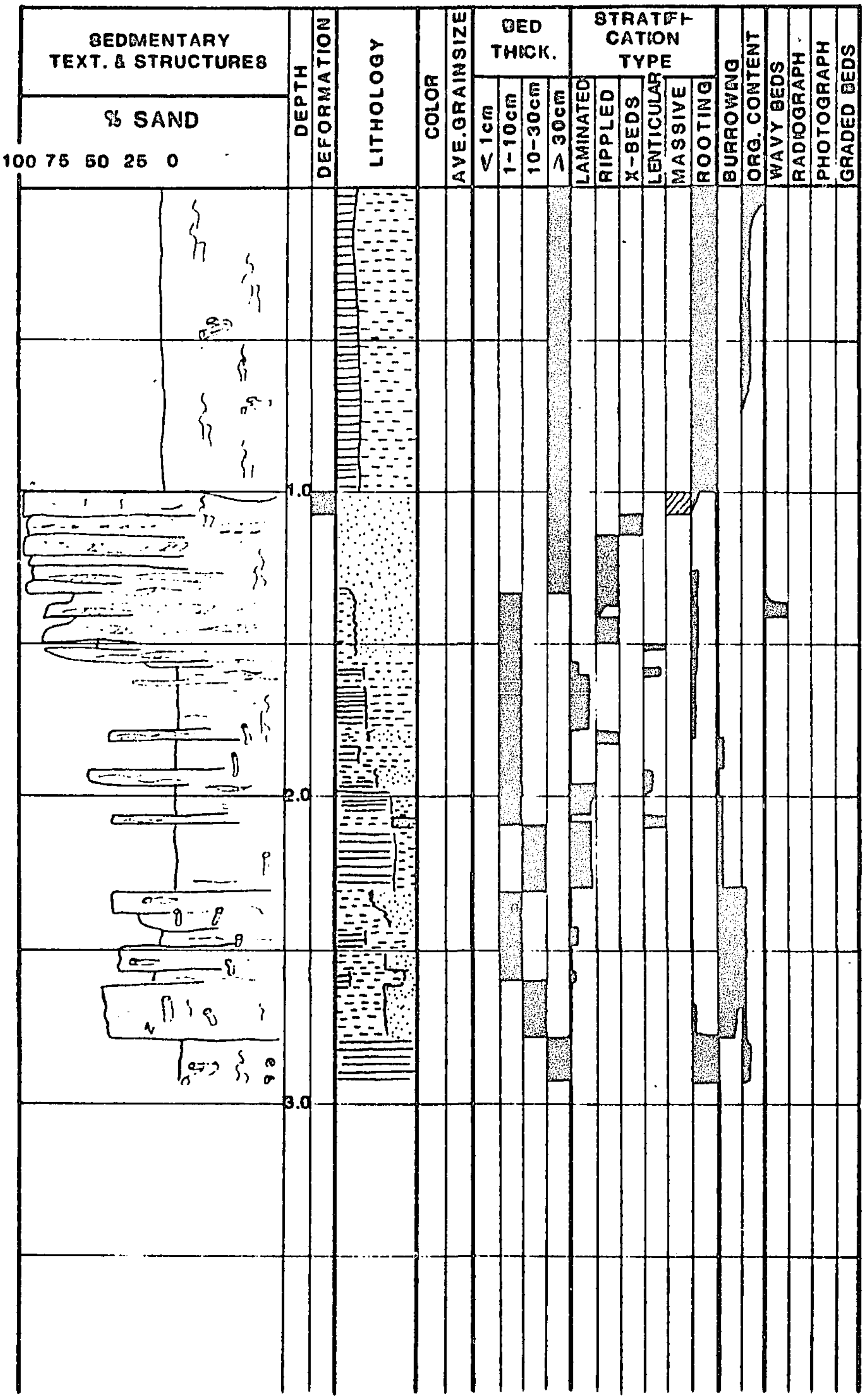

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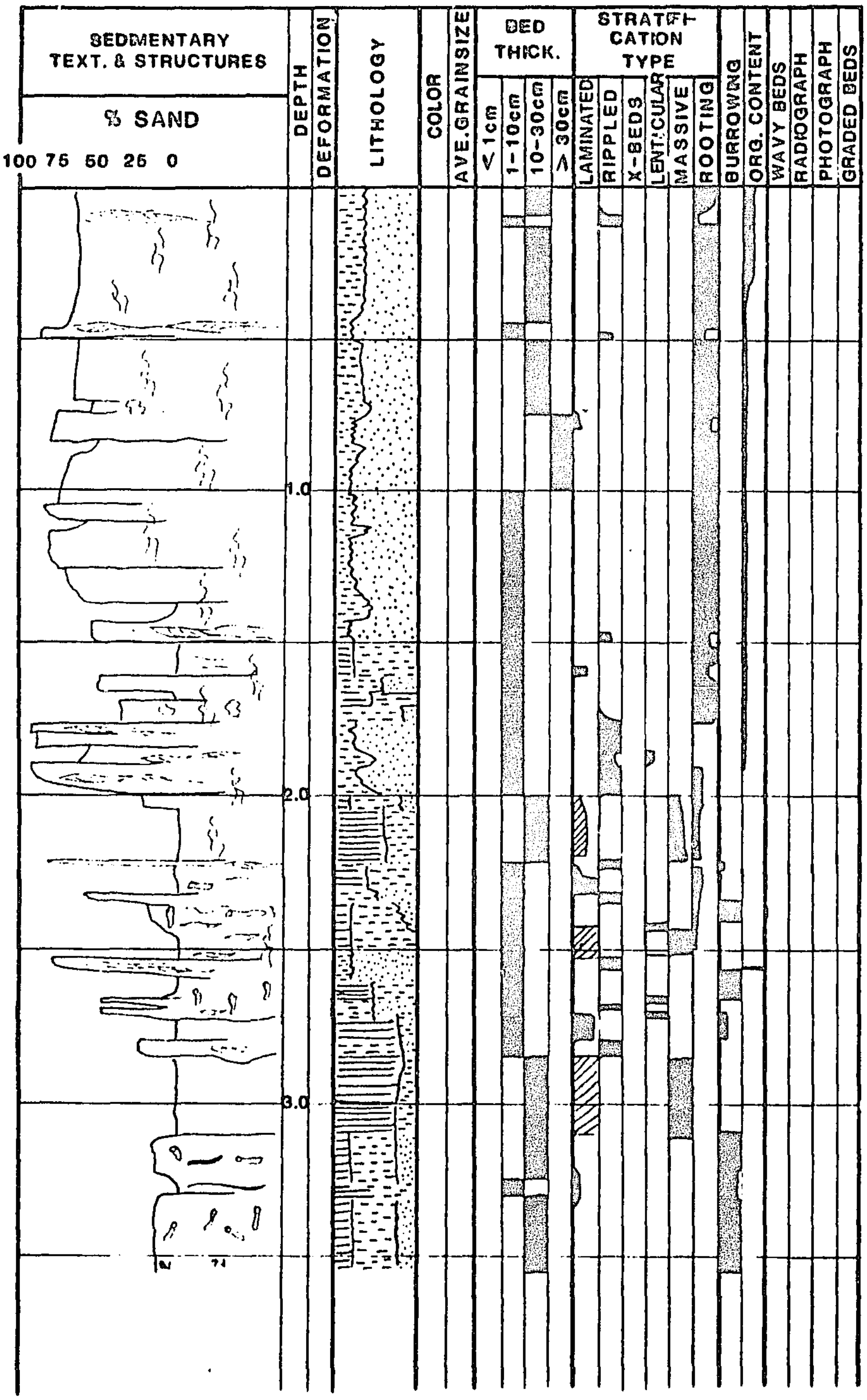

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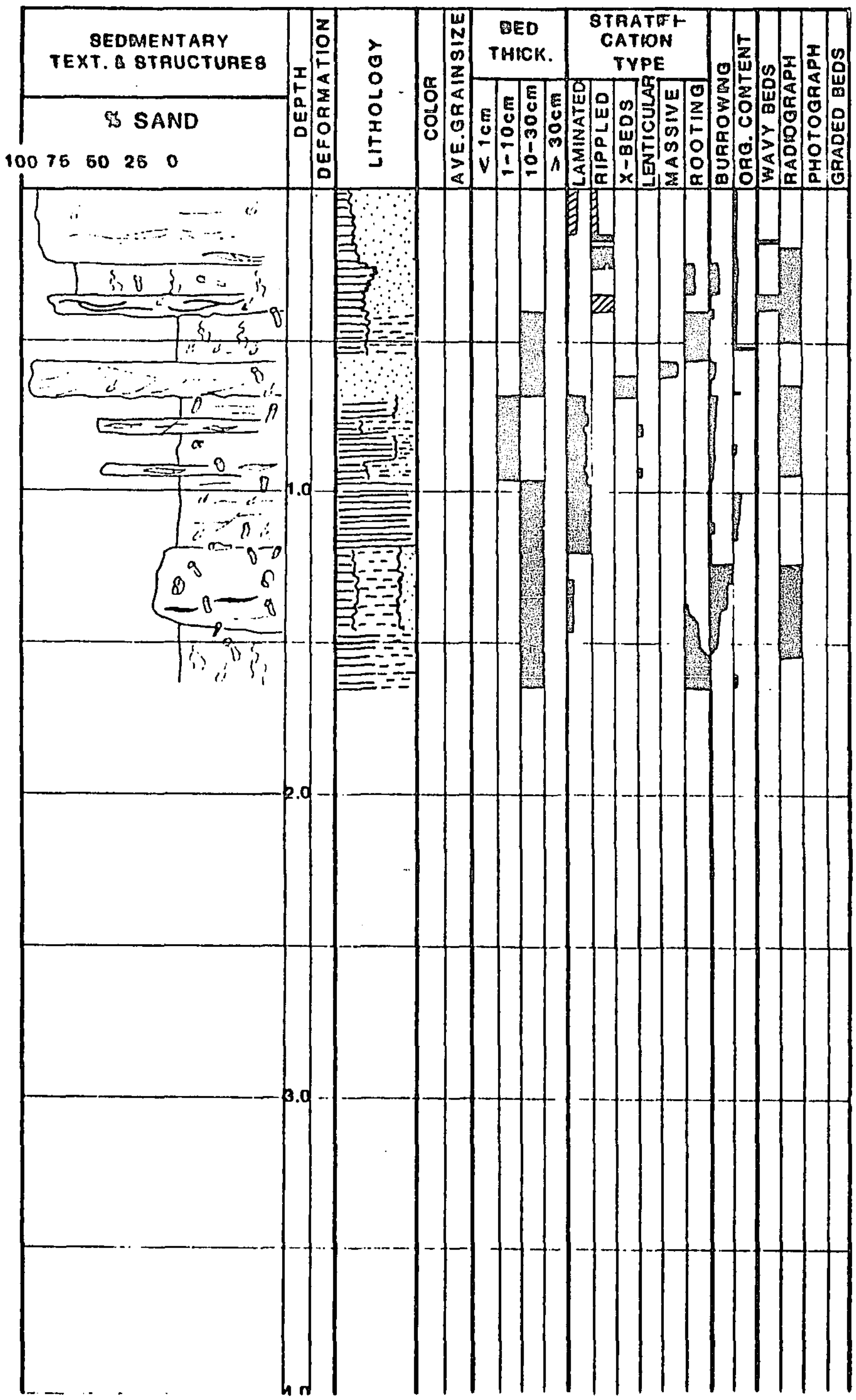

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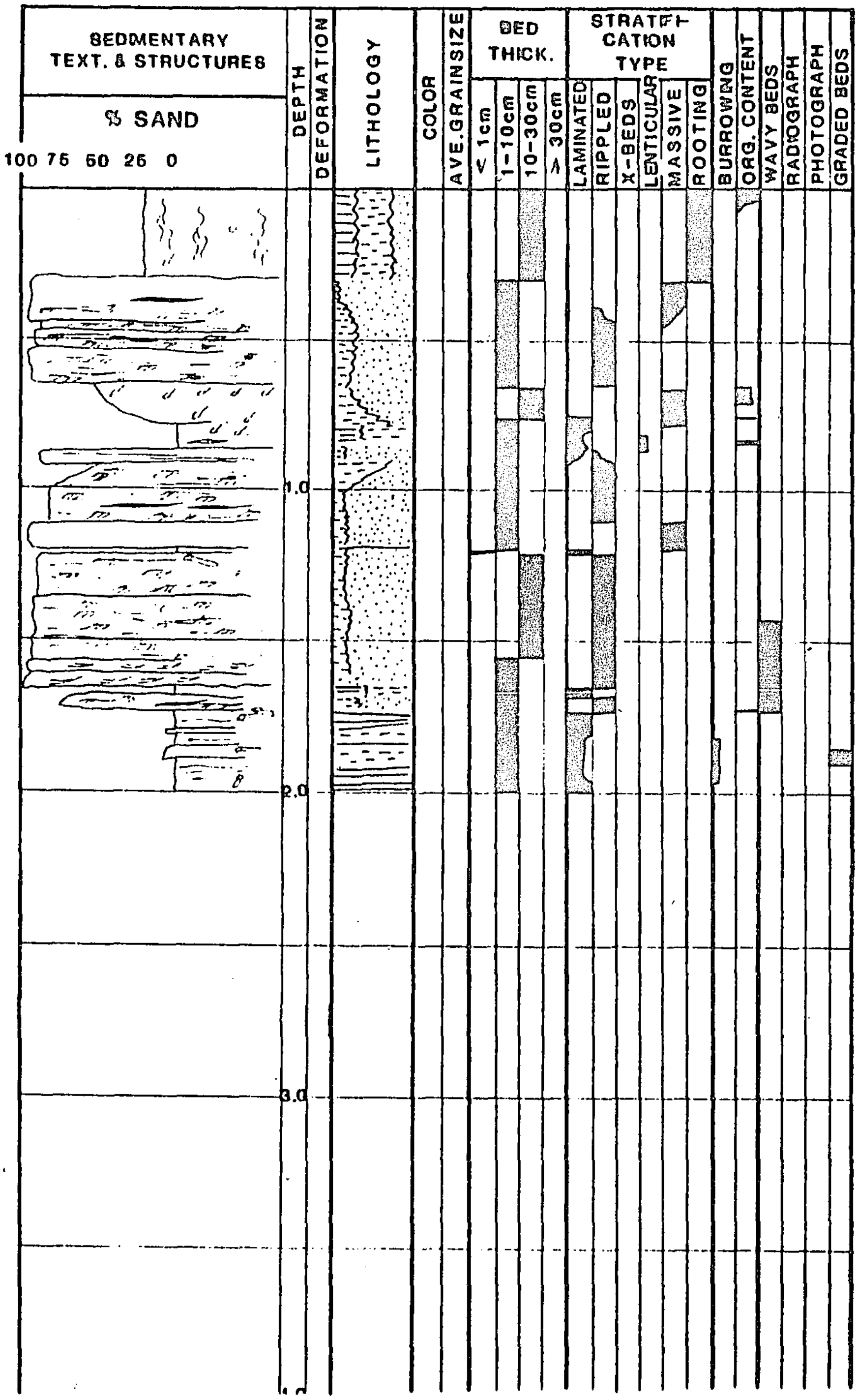

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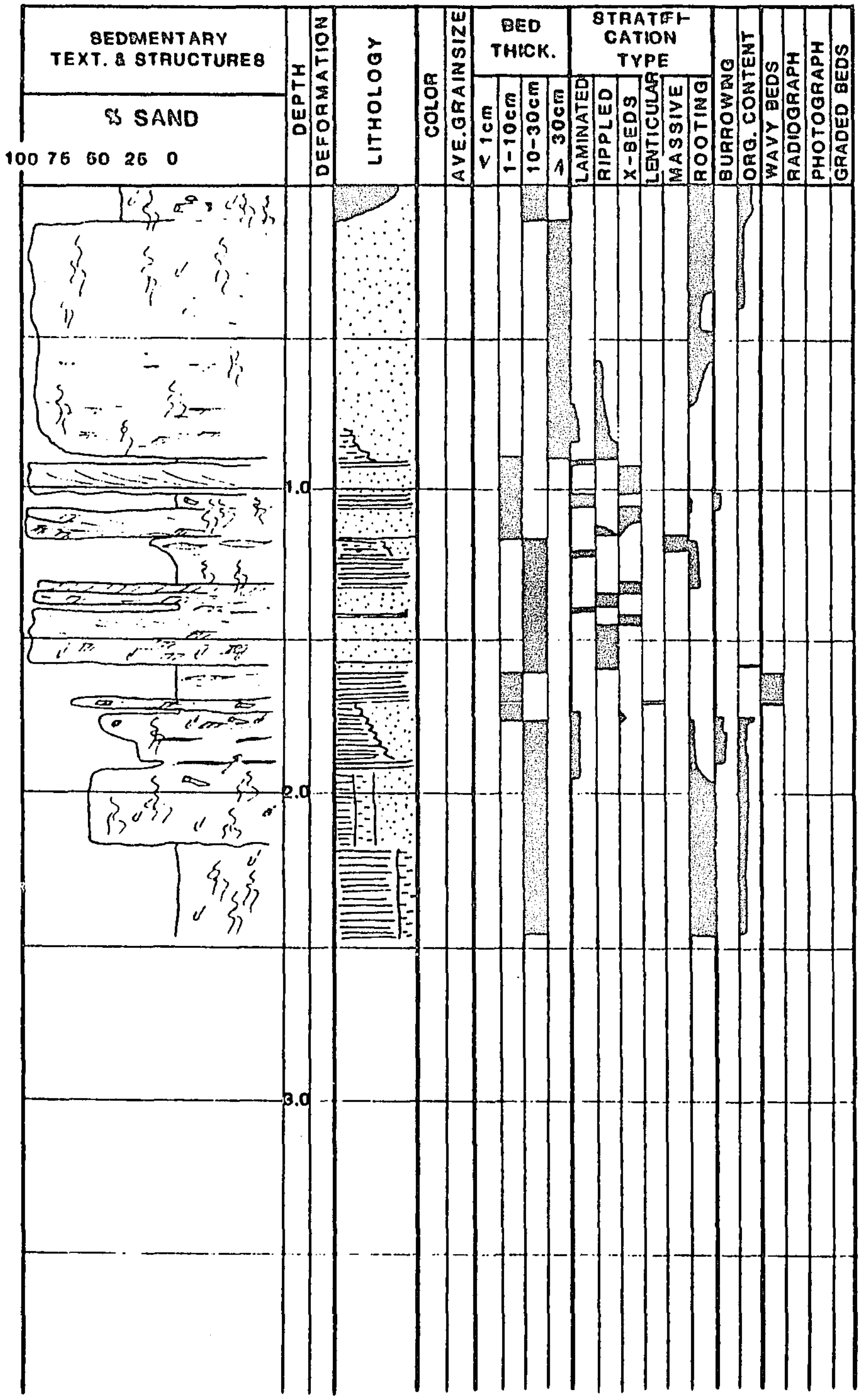
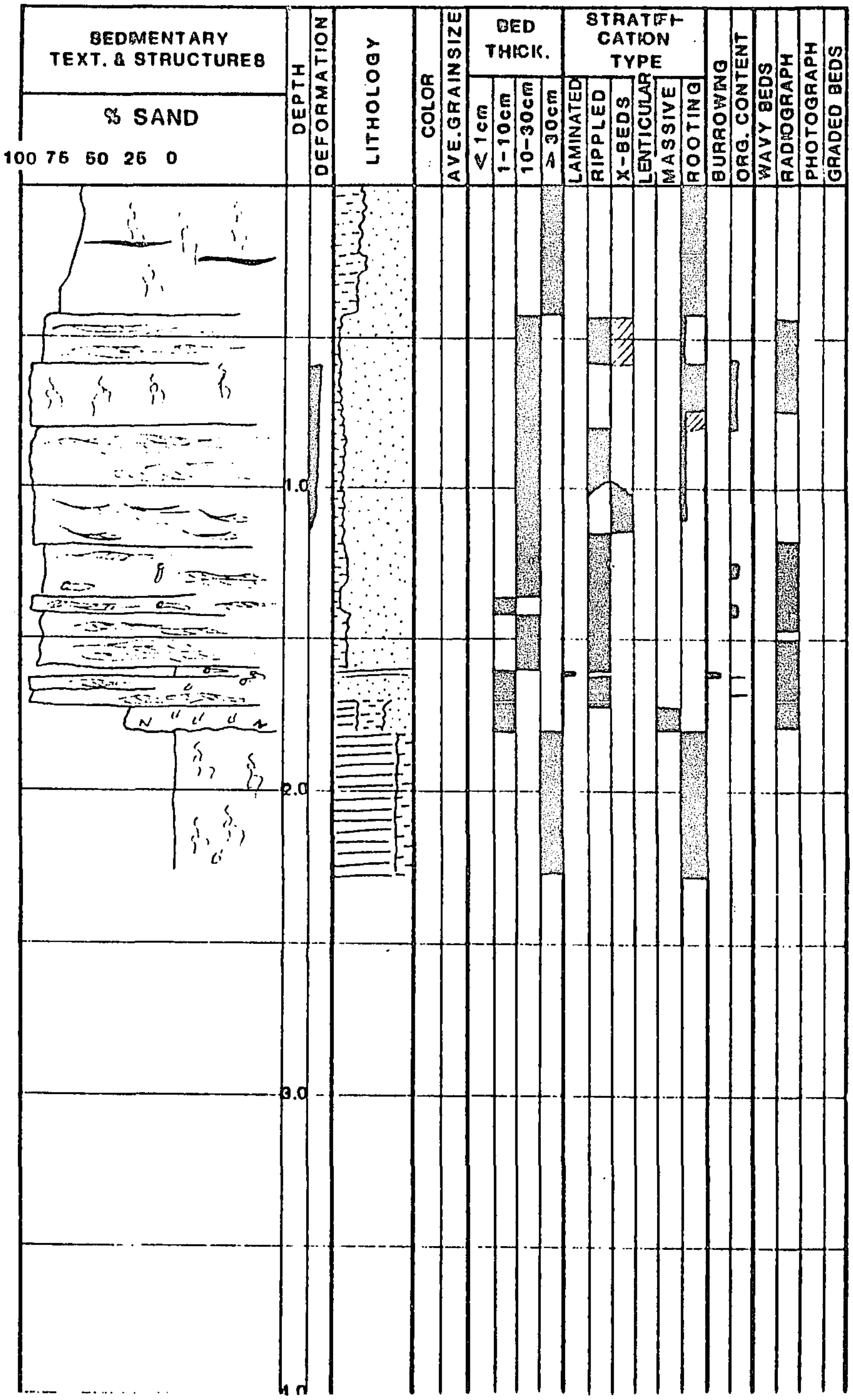


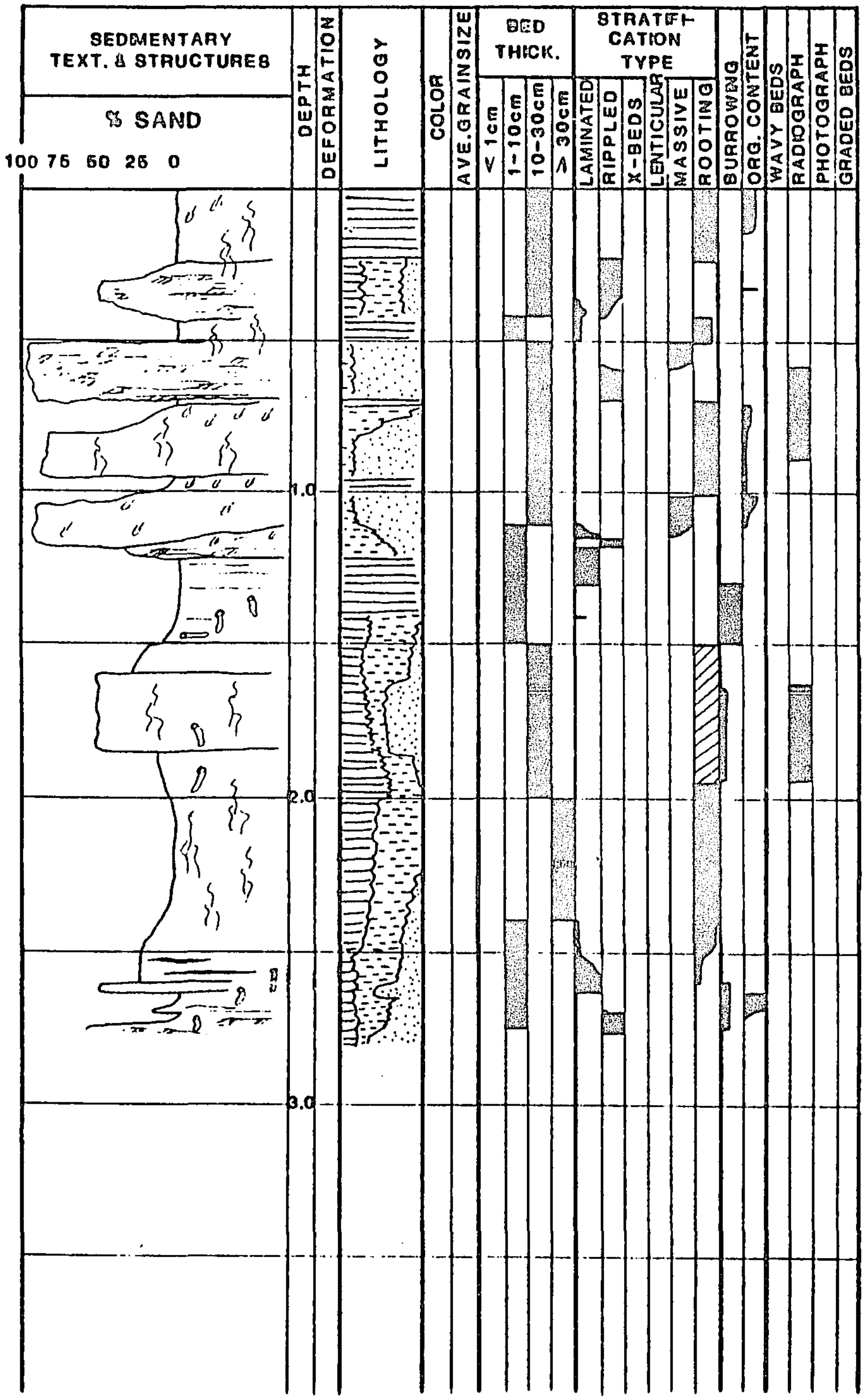
CORE NUMBER FP-25 CORE DEPTH (M) 2.27

LOCATION LAKE FAUSSE POINTE



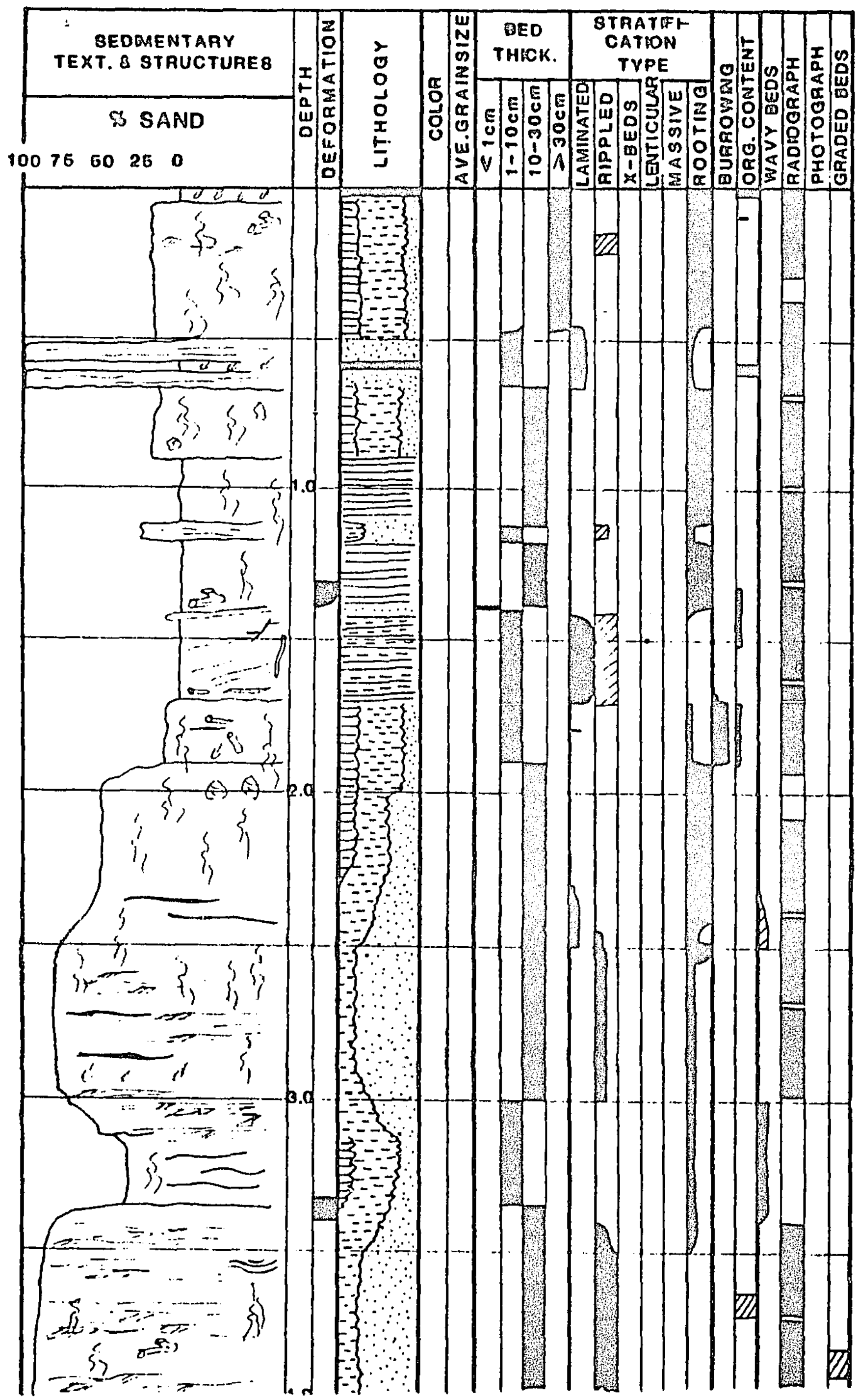
CORE NUMBER FP-26 CORE DEPTH (M) 2.76

LOCATION LAKE FAUSSE POINTE



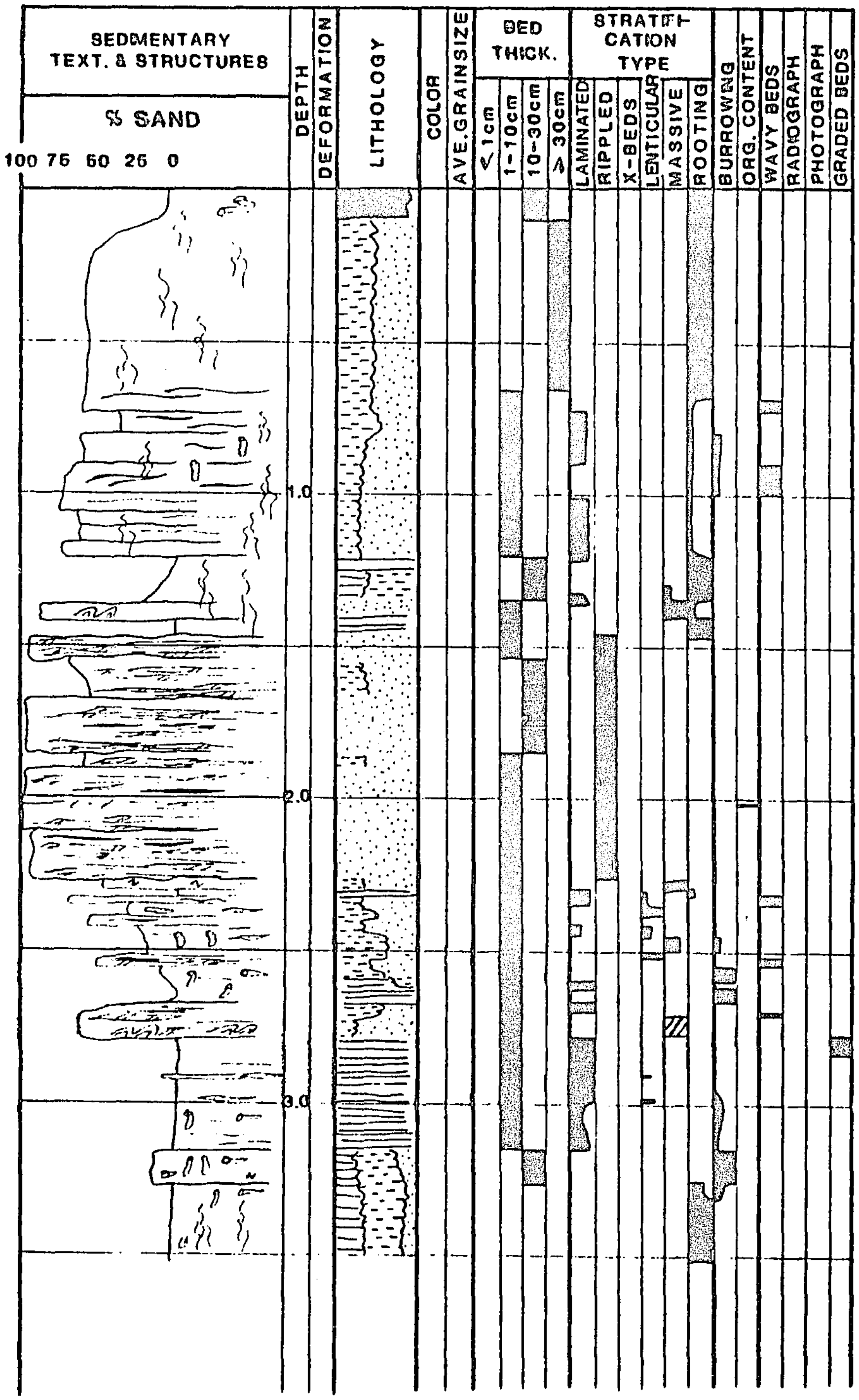
CORE NUMBER FP-27 CORE DEPTH (M) 4.18

LOCATION LAKE FAUSSE POINTE



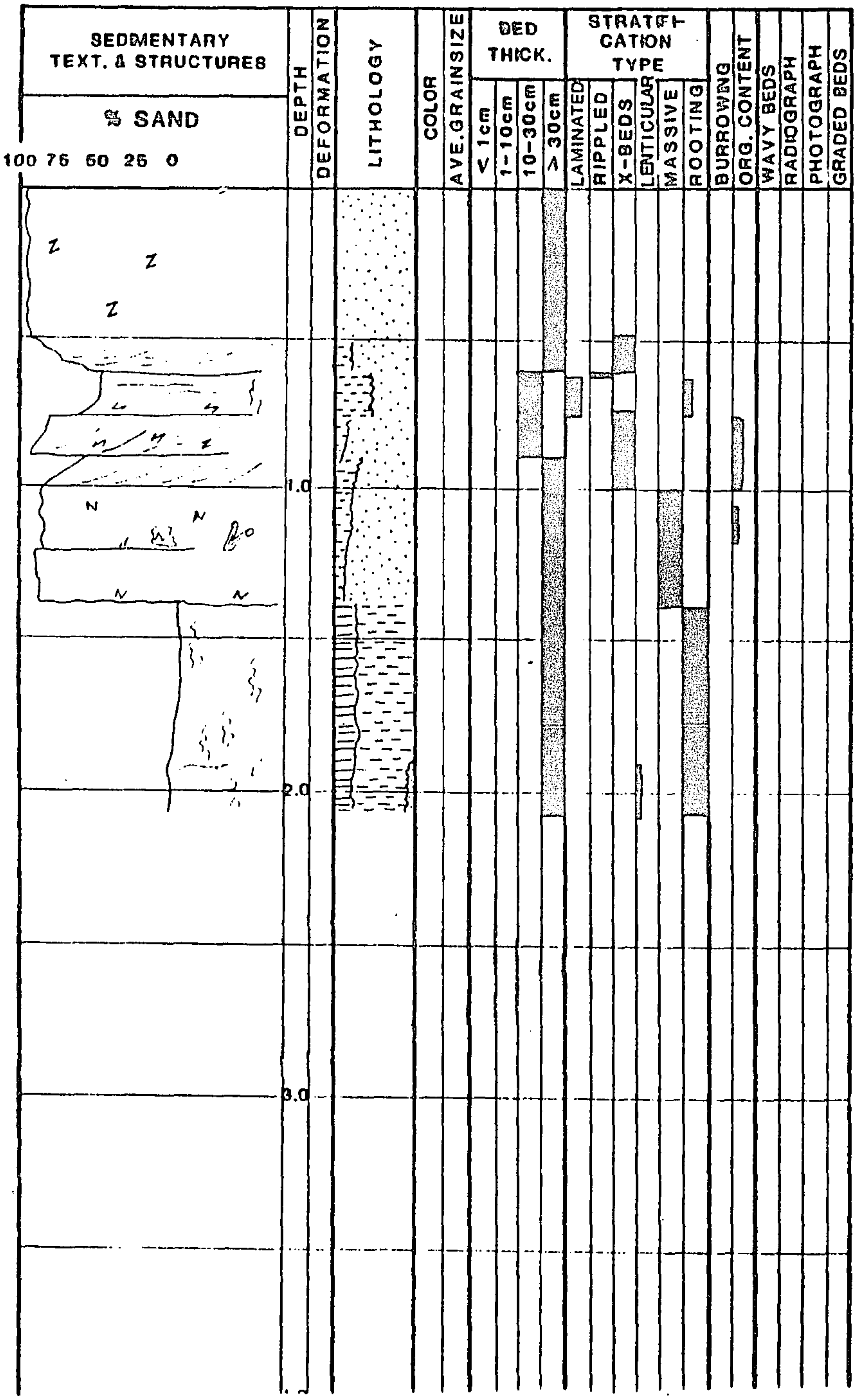
CORE NUMBER FP-28 CORE DEPTH (M) 3.51

LOCATION LAKE FAUSSE POINTE



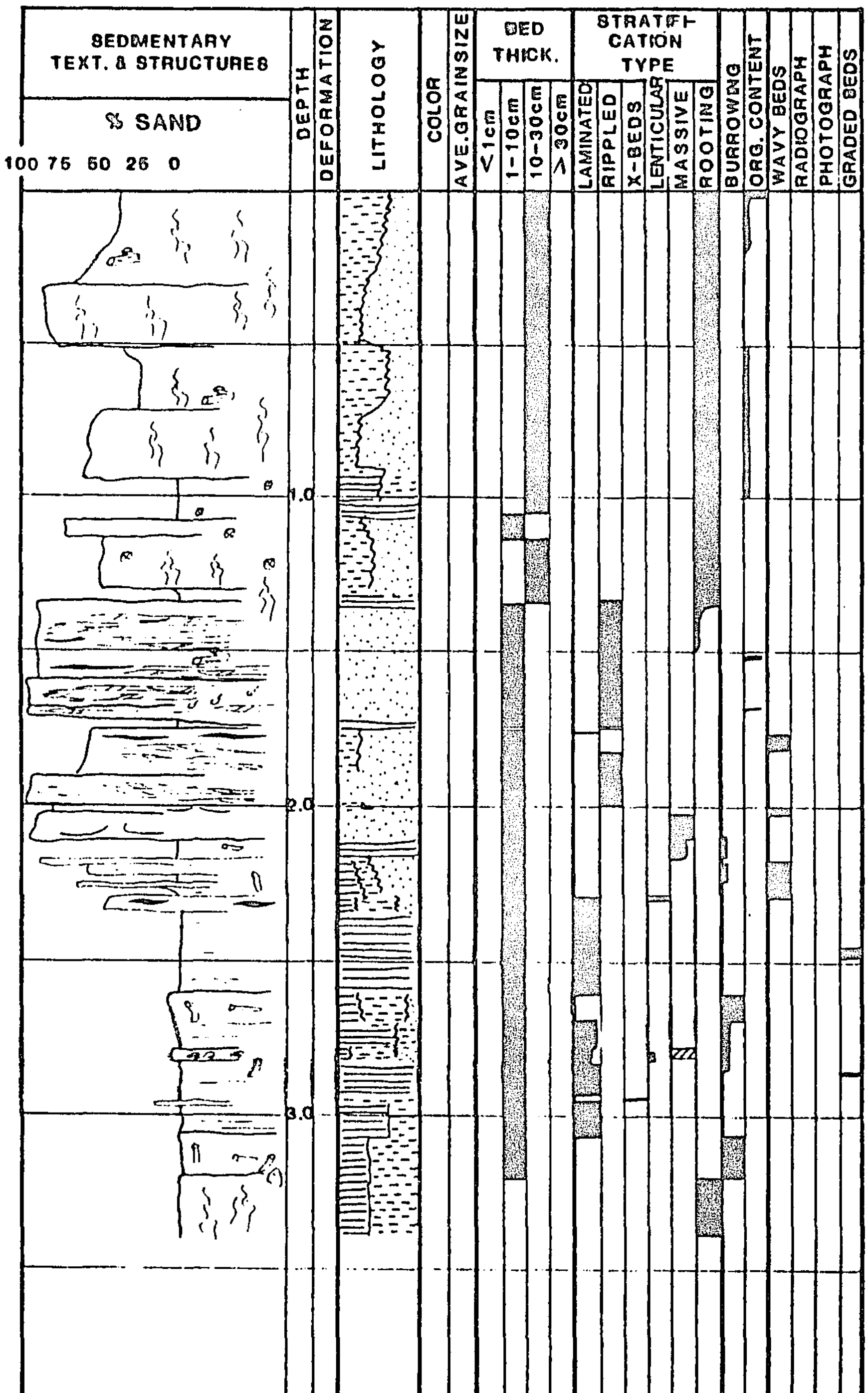
CORE NUMBER FP-29 CORE DEPTH (M) 2.07

LOCATION LAKE FAUSSE POINTE



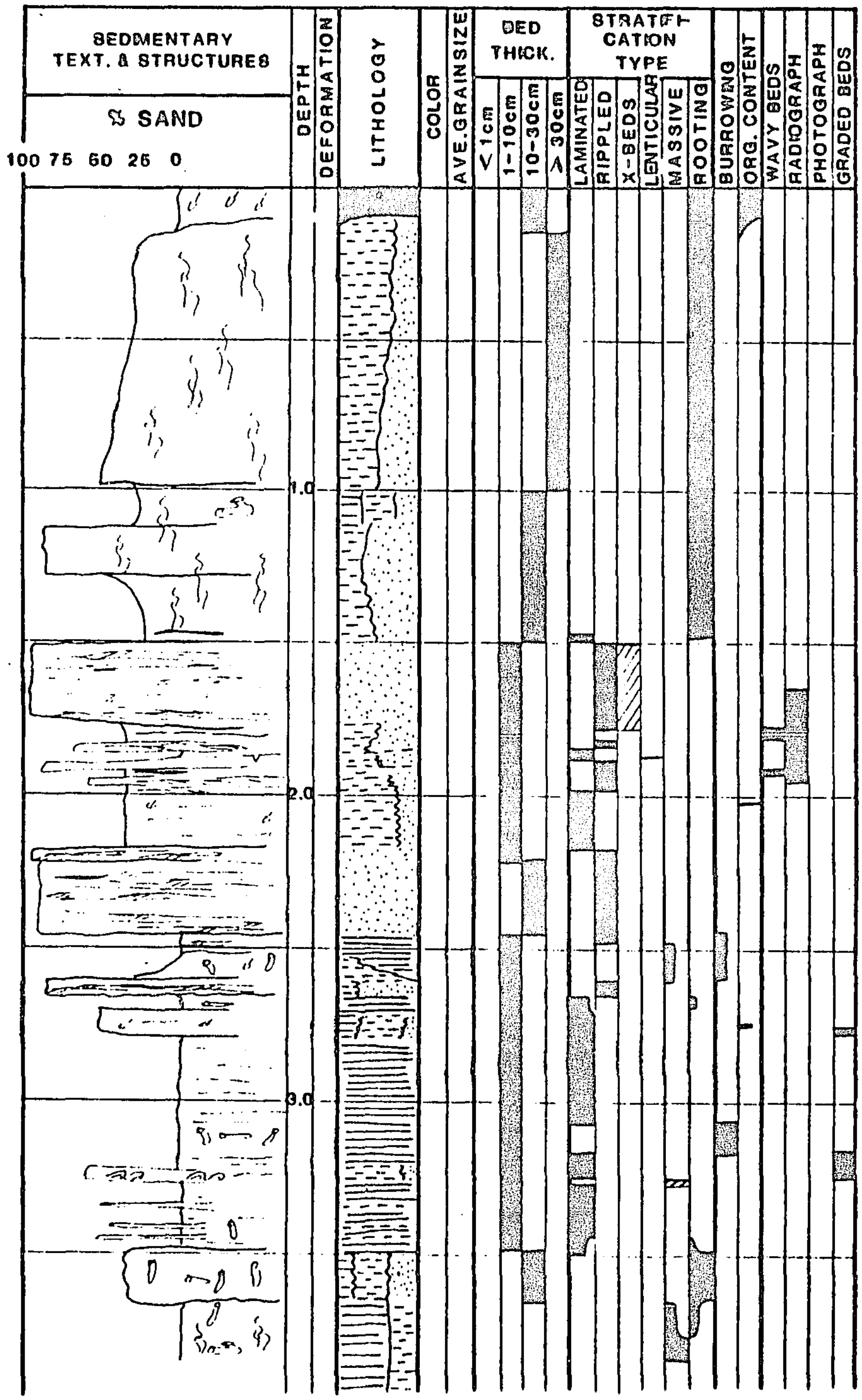
CORE NUMBER FP-30 CORE DEPTH (M) 3.38

LOCATION LAKE FAUSSE POINTE



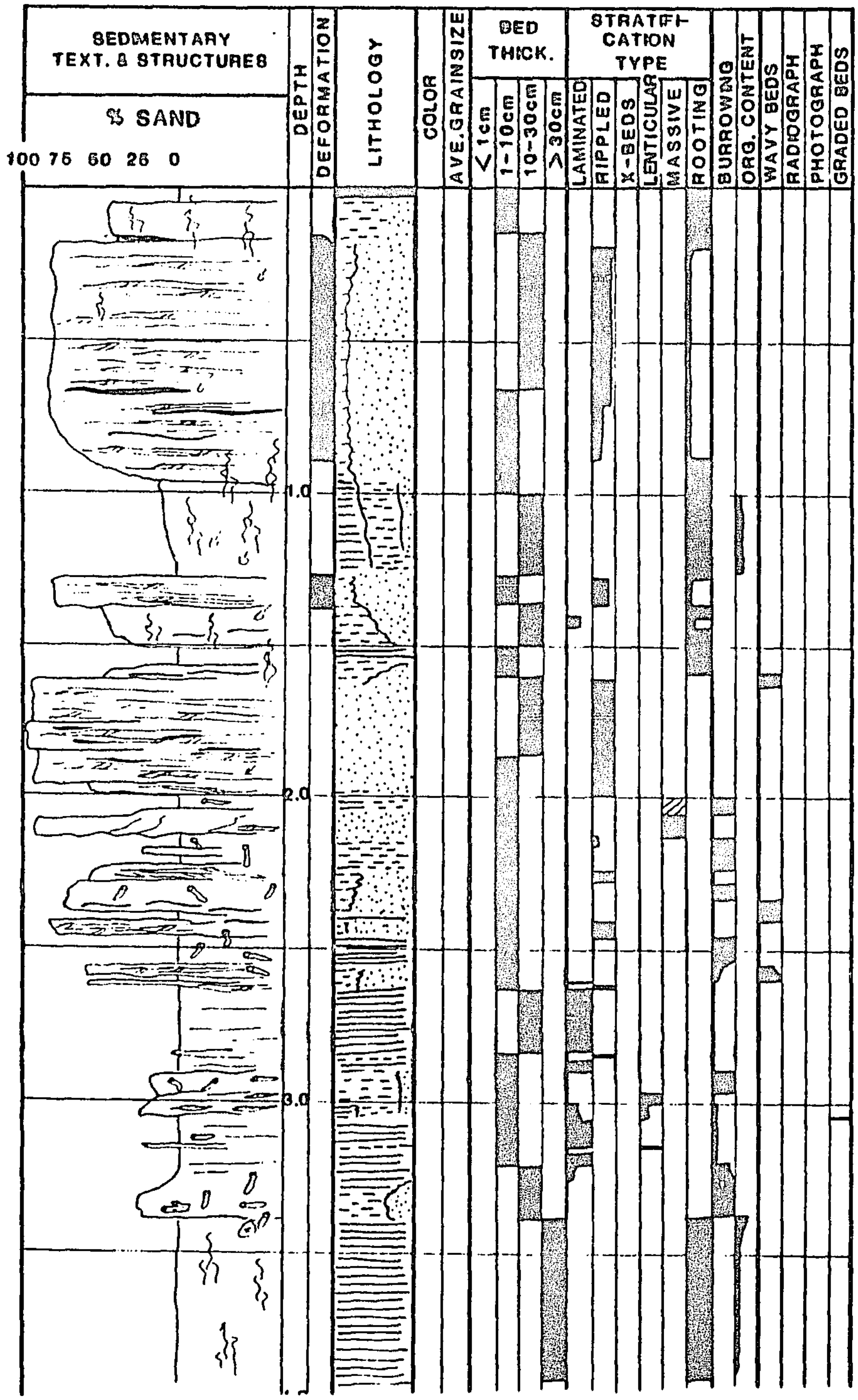
CORE NUMBER FP-31 CORE DEPTH (M) 3.85

LOCATION LAKE FAUSSE POINTE



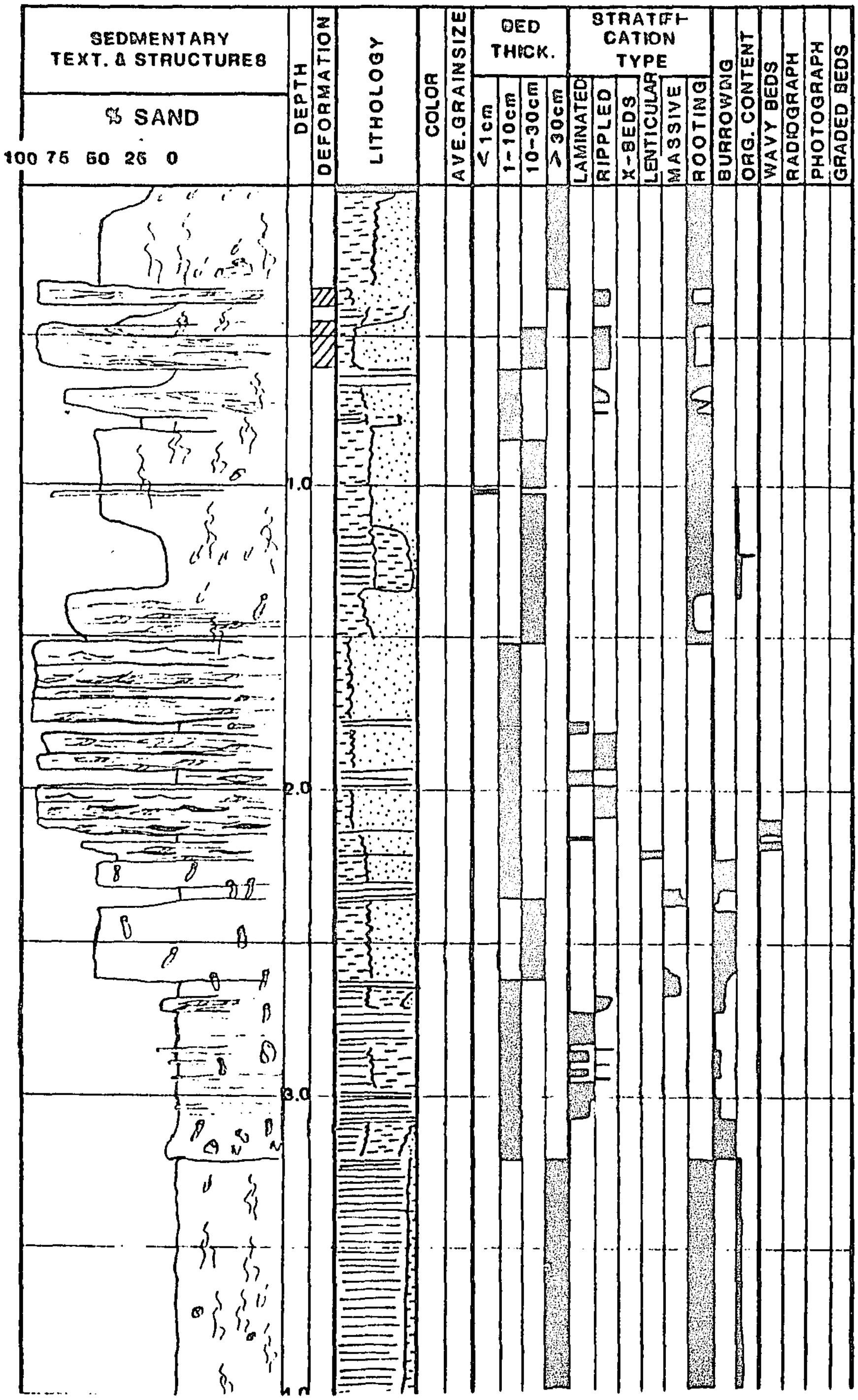
CORE NUMBER FP-32 CORE DEPTH (M) 3.94

LOCATION LAKE FAUSSE POINTE



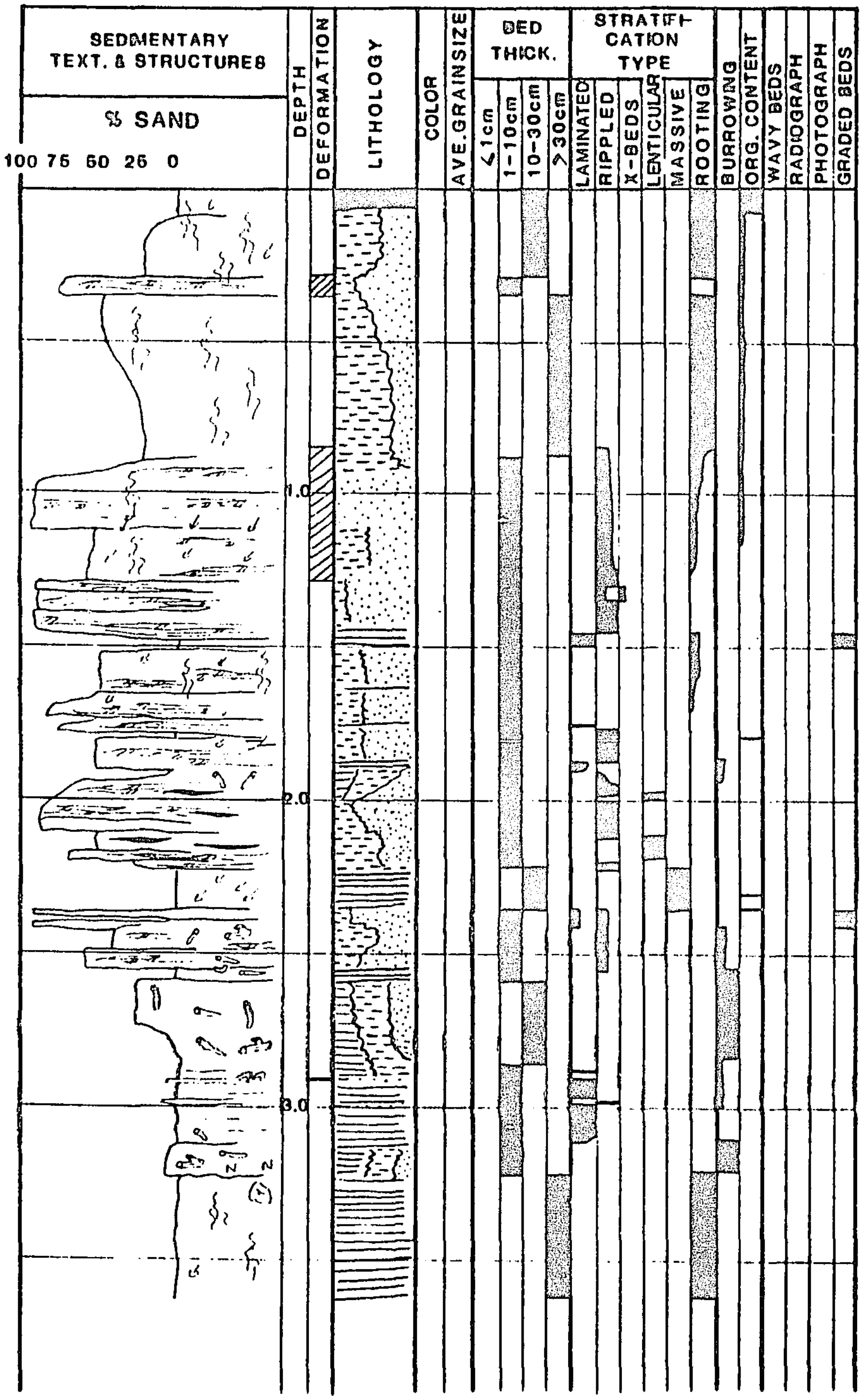
CORE NUMBER FP-33 CORE DEPTH (M) 4.11

LOCATION LAKE FAUSSE POINTE



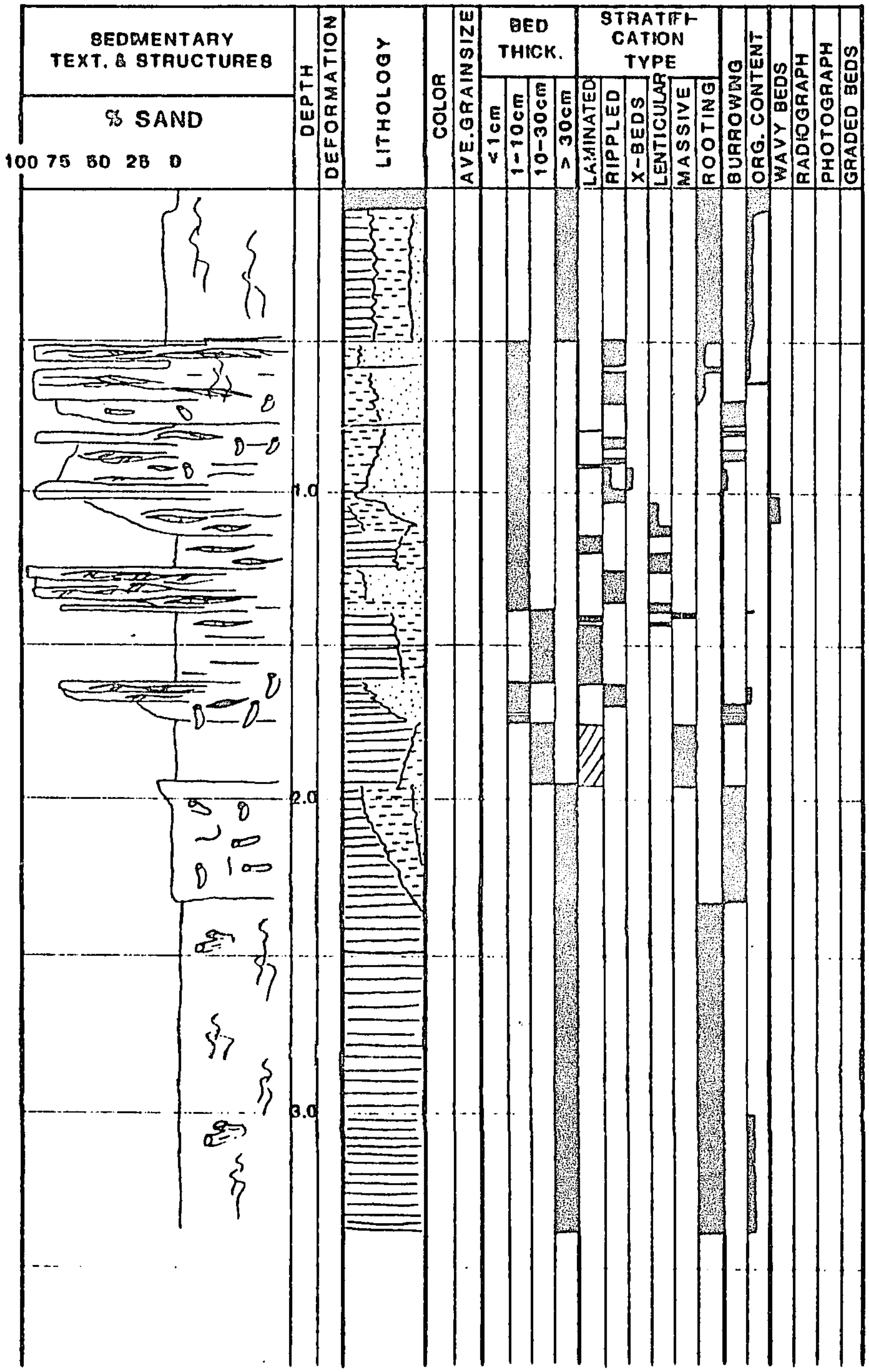
CORE NUMBER FP-34 CORE DEPTH (M) 3.62

LOCATION LAKE FAUSSE POINTE



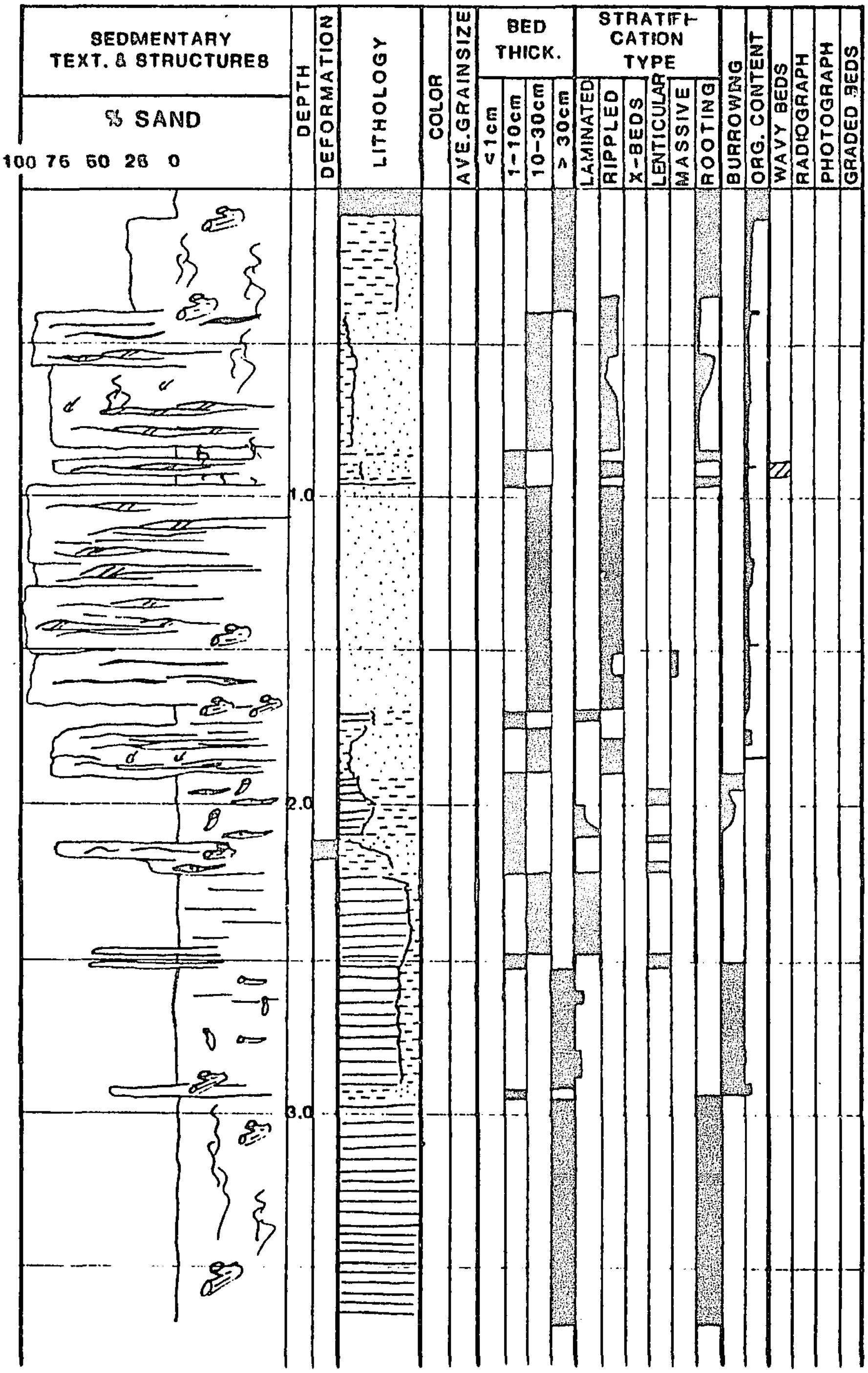
CORE NUMBER FP-35 CORE DEPTH (M) 3.38

LOCATION LAKE FAUSSE POINTE



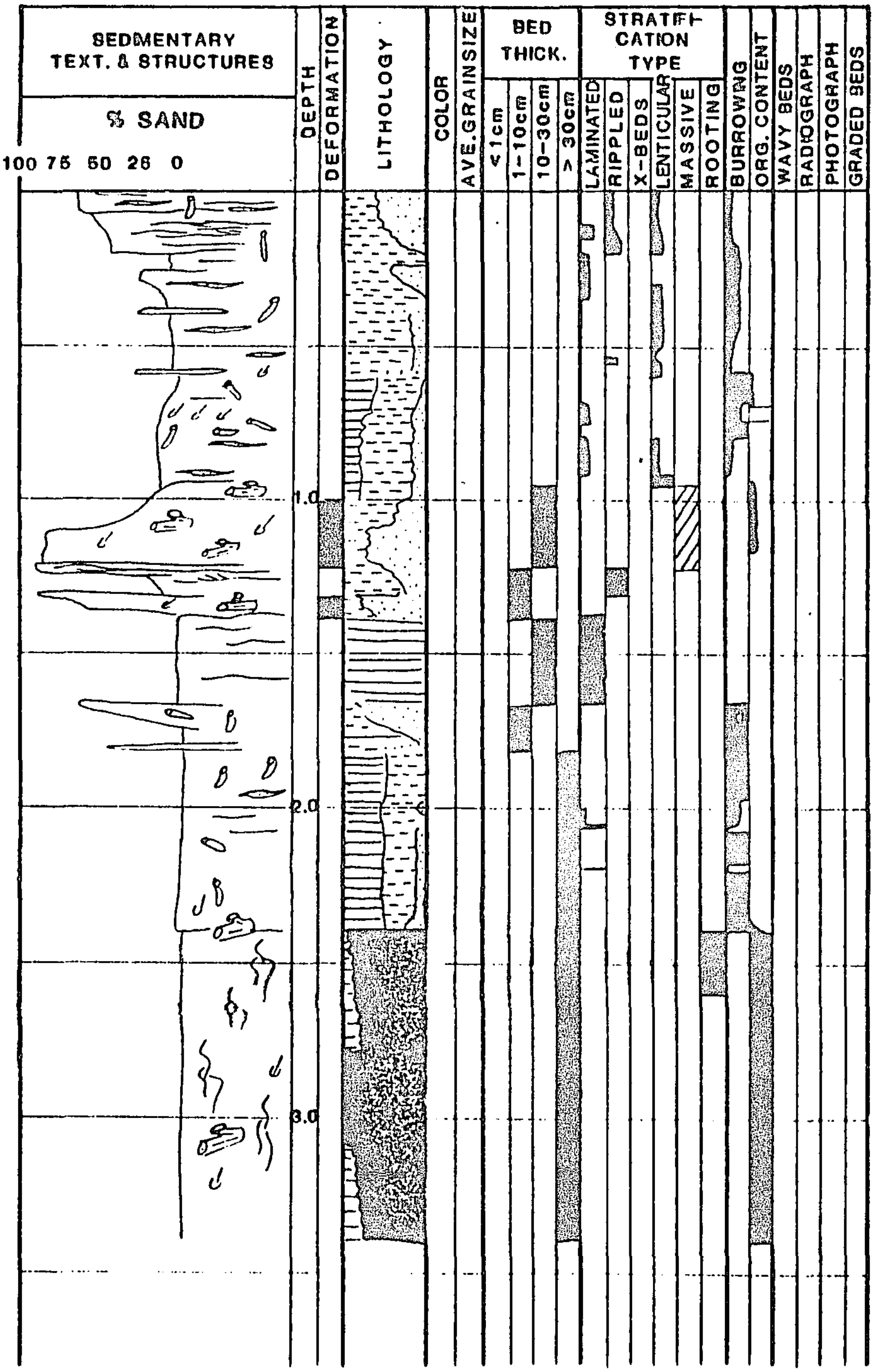
CORE NUMBER FP-36 CORE DEPTH (M) 3.68

LOCATION LAKE FAUSSE POINTE



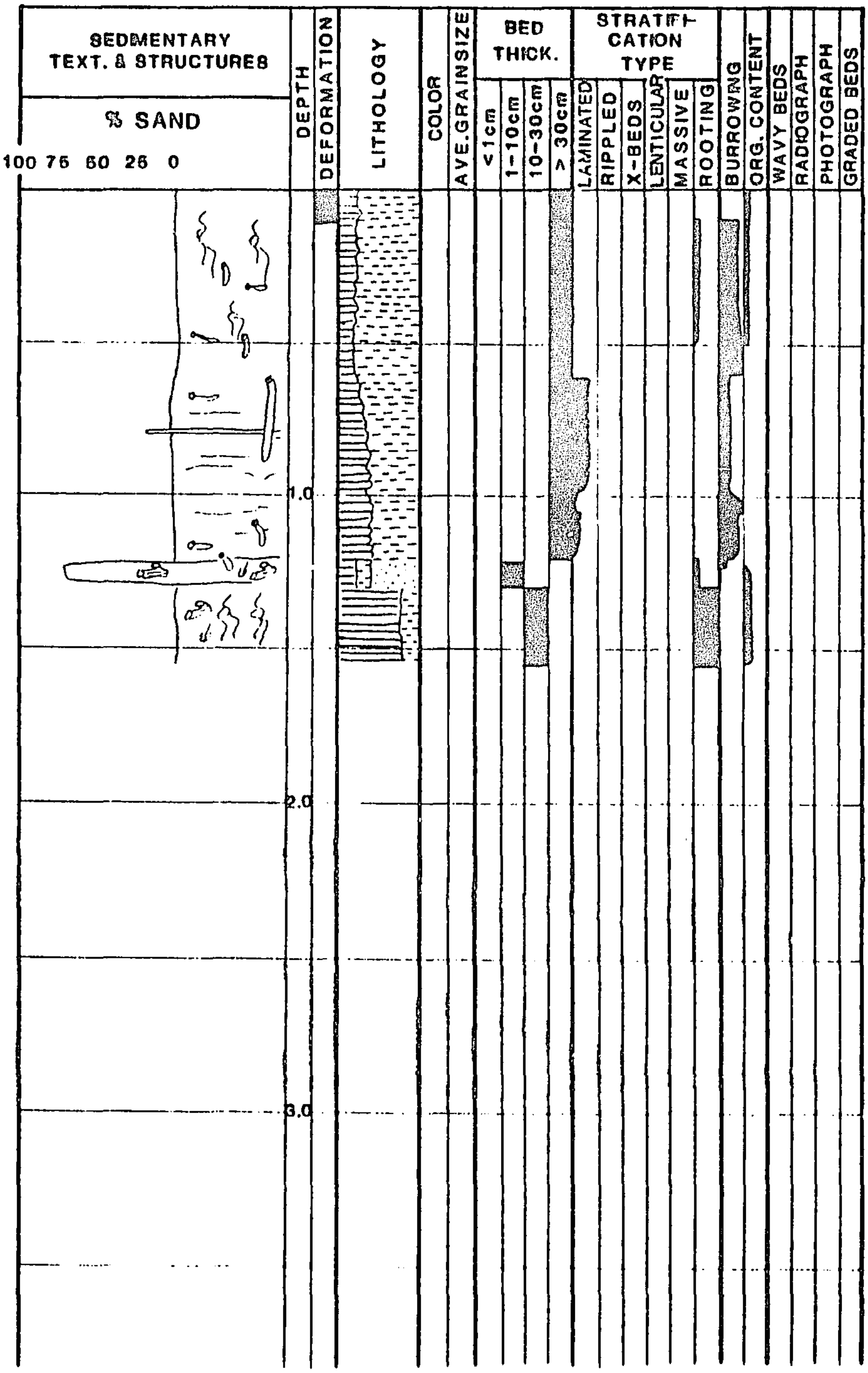
CORE NUMBER FP-37 CORE DEPTH (M) 3.40

LOCATION LAKE FAUSSE POINTE



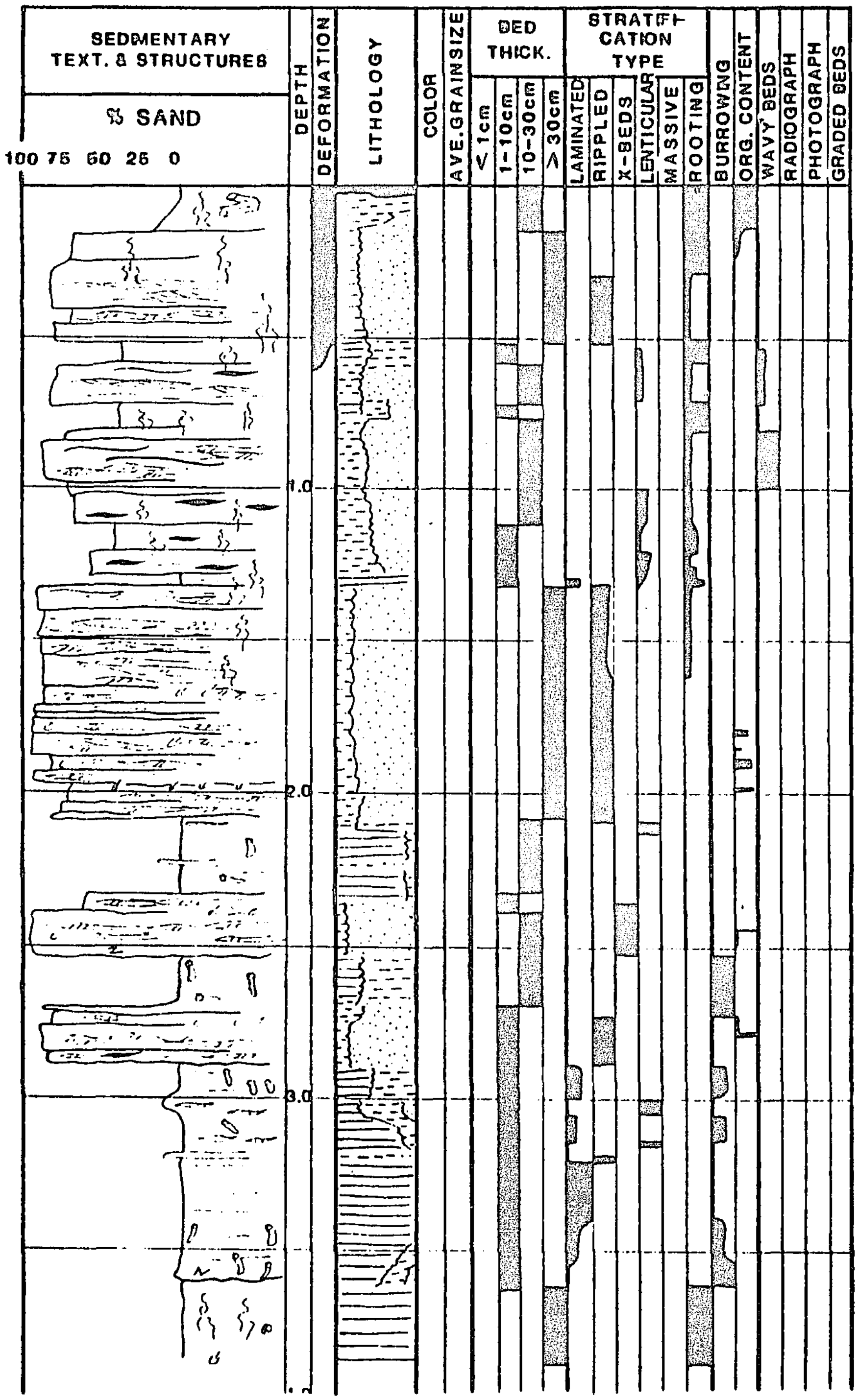
CORE NUMBER FP-38 CORE DEPTH (M) 1.55

LOCATION LAKE FAUSSE POINTE



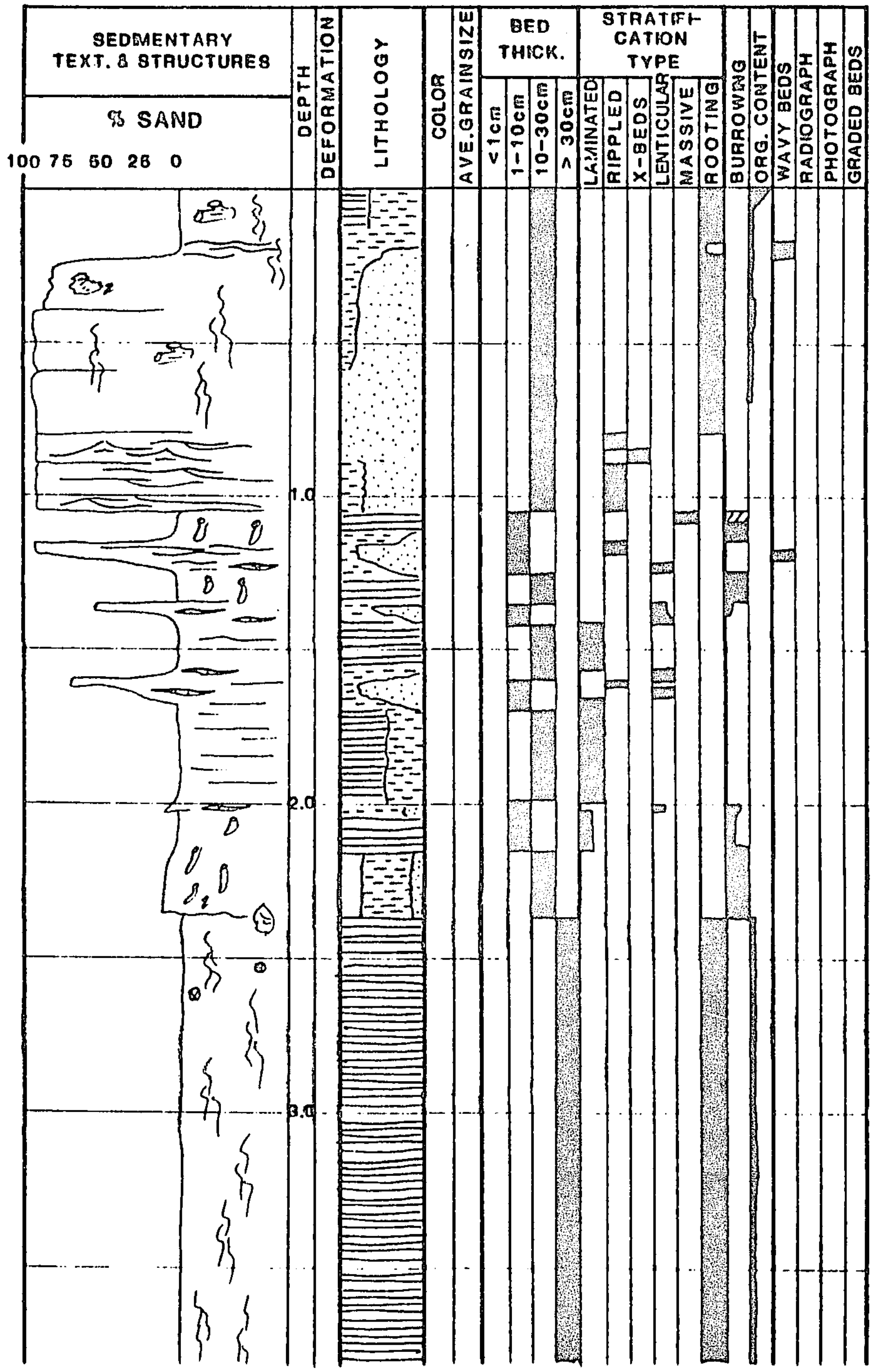
CORE NUMBER FP-39 CORE DEPTH (M) 3.88

LOCATION LAKE FAUSSE POINTE



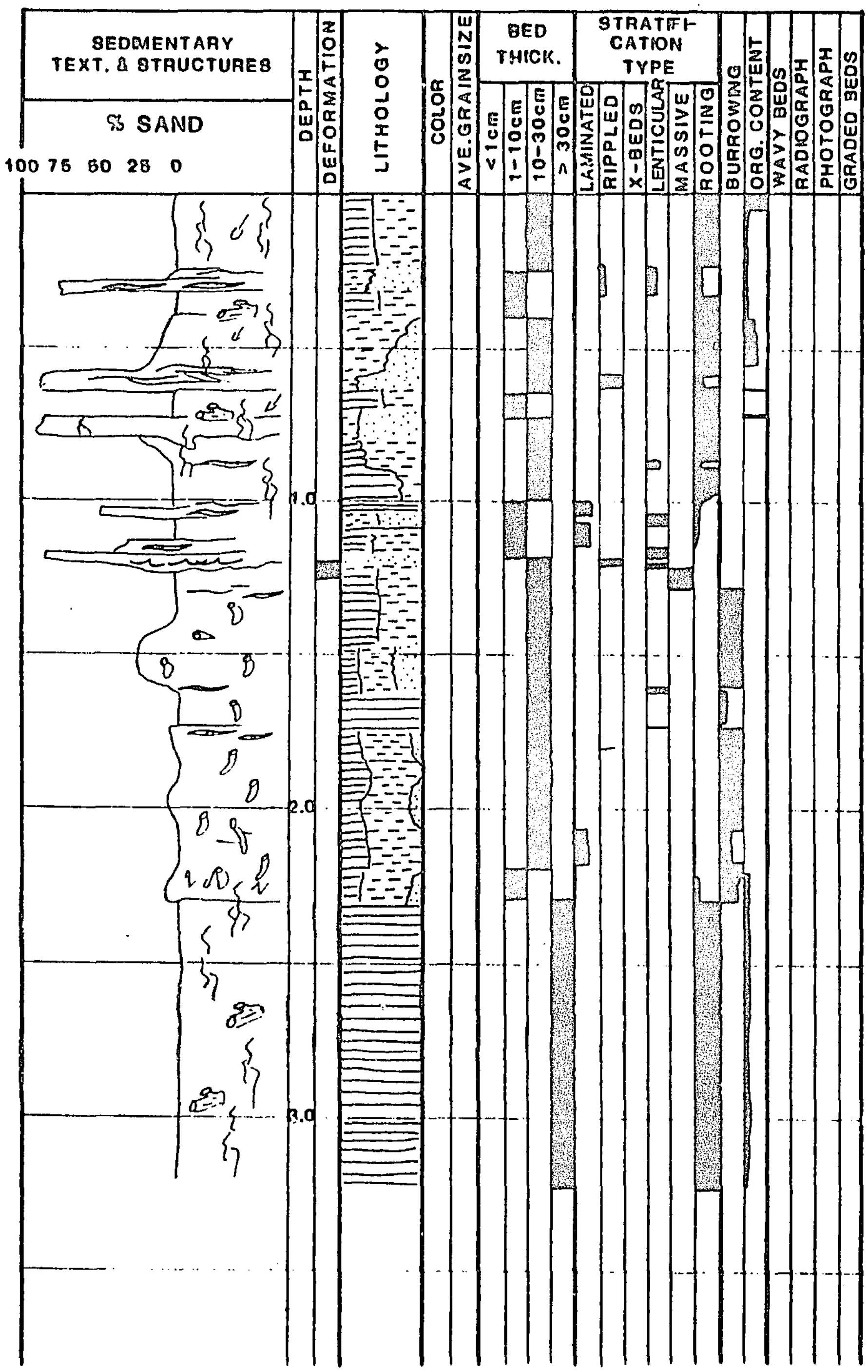
CORE NUMBER FP-40 CORE DEPTH (M) 4.25

LOCATION LAKE FAUSSE POINTE



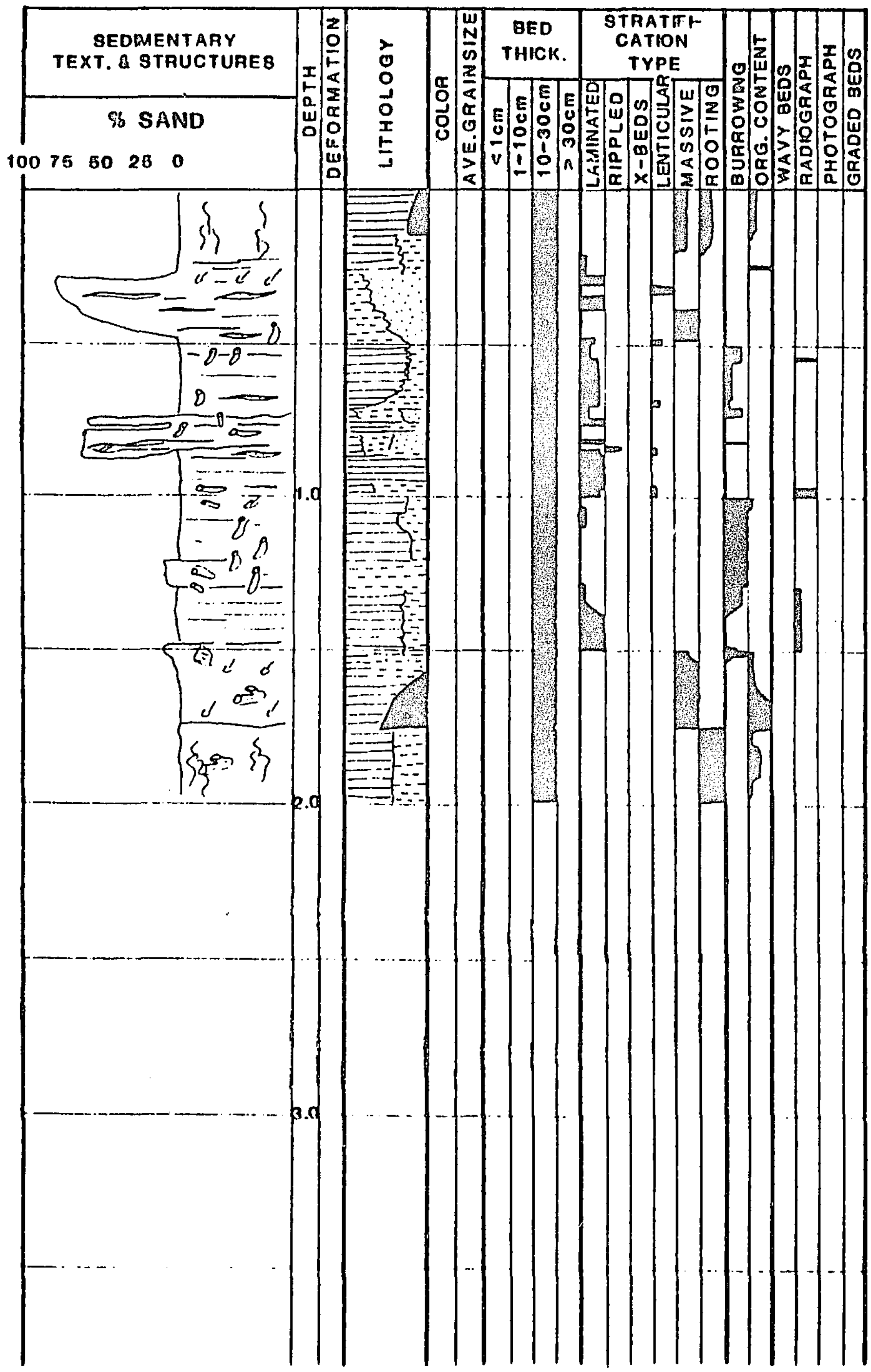
CORE NUMBER FP-41 CORE DEPTH (M) 3.24

LOCATION LAKE FAUSSE POINTE



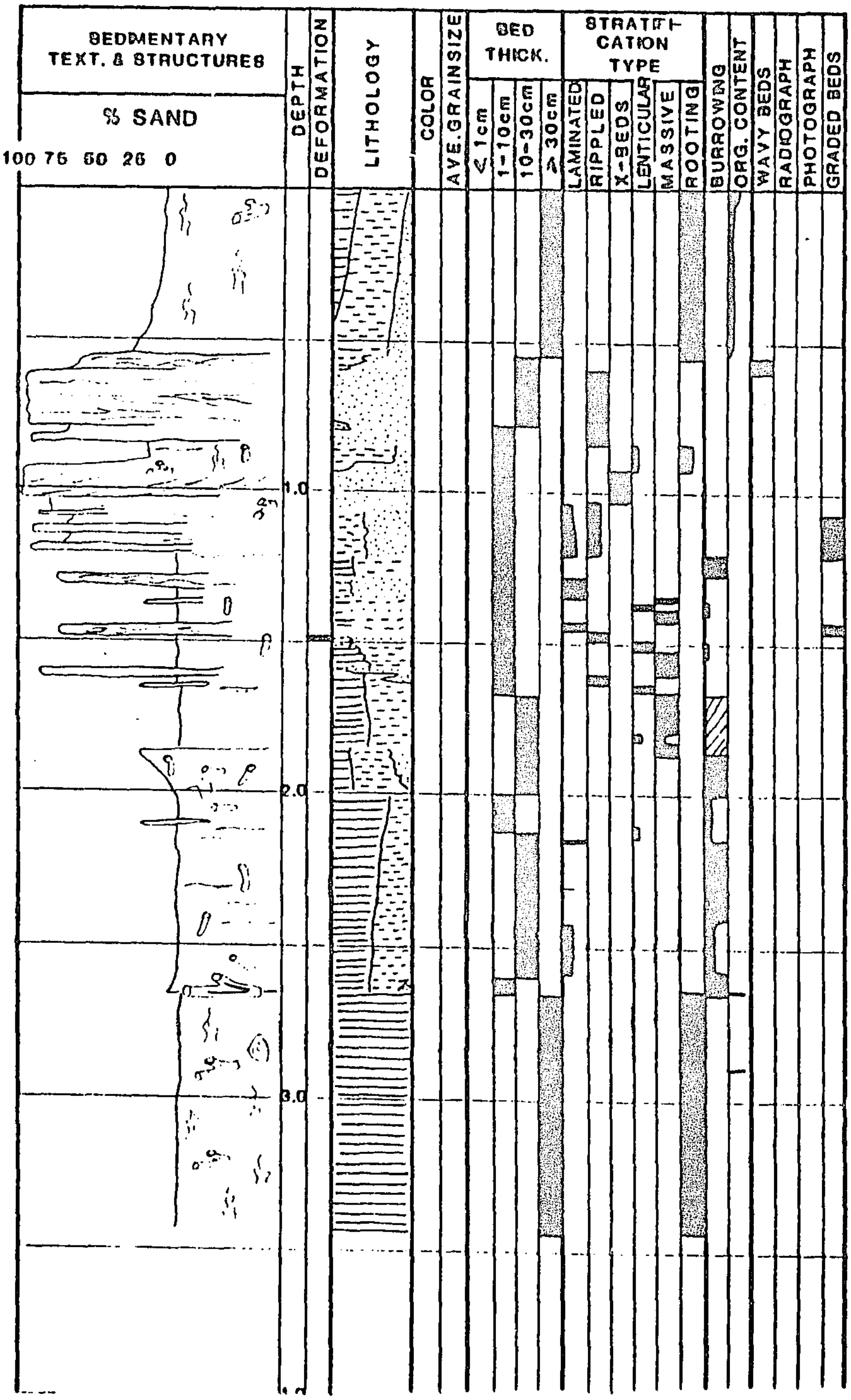
CORE NUMBER FP-42 CORE DEPTH (M) 1.99

LOCATION LAKE FAUSSE POINTE



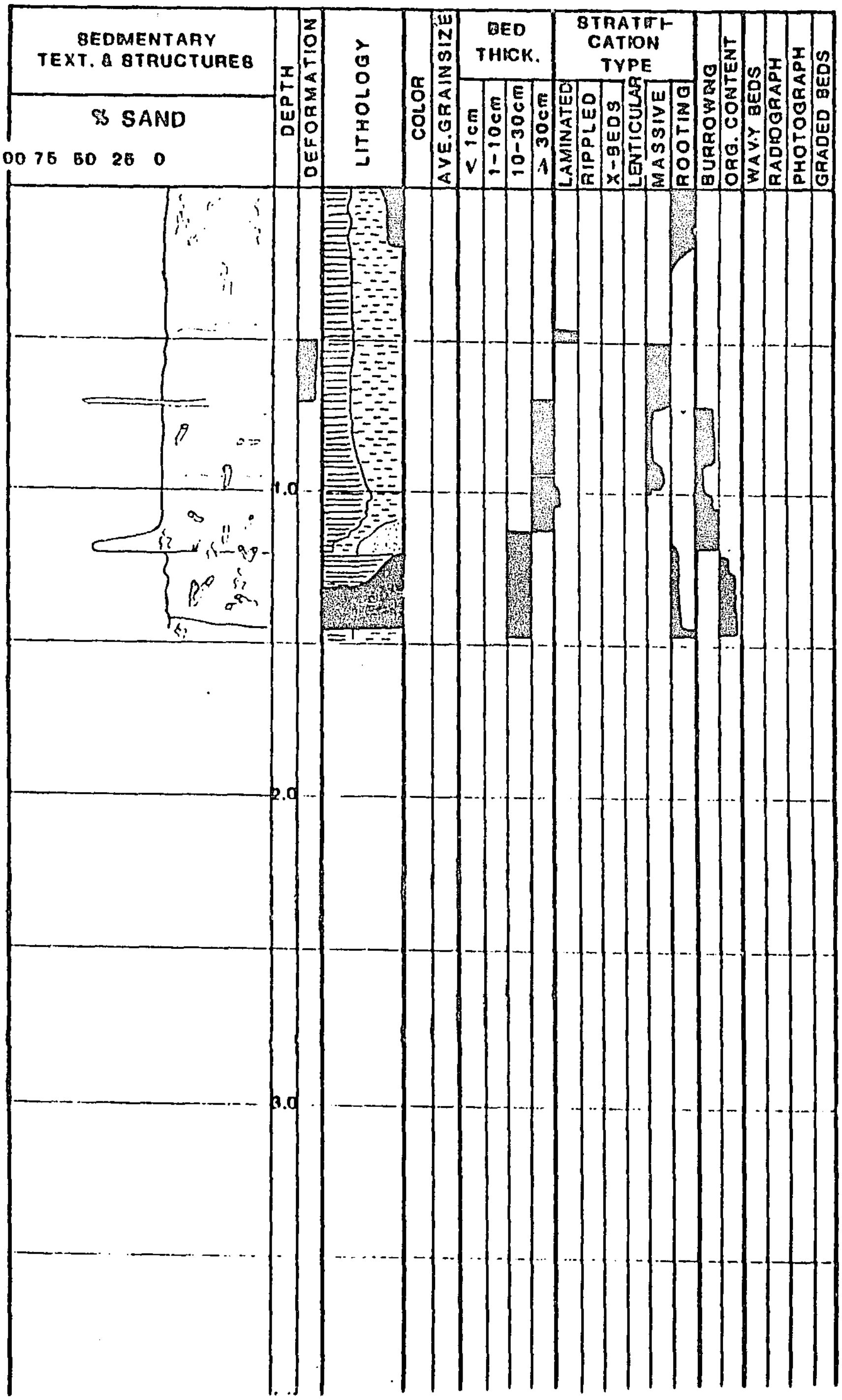
CORE NUMBER FP-43 CORE DEPTH (M) 3.44

LOCATION LAKE FAUSSE POINTE



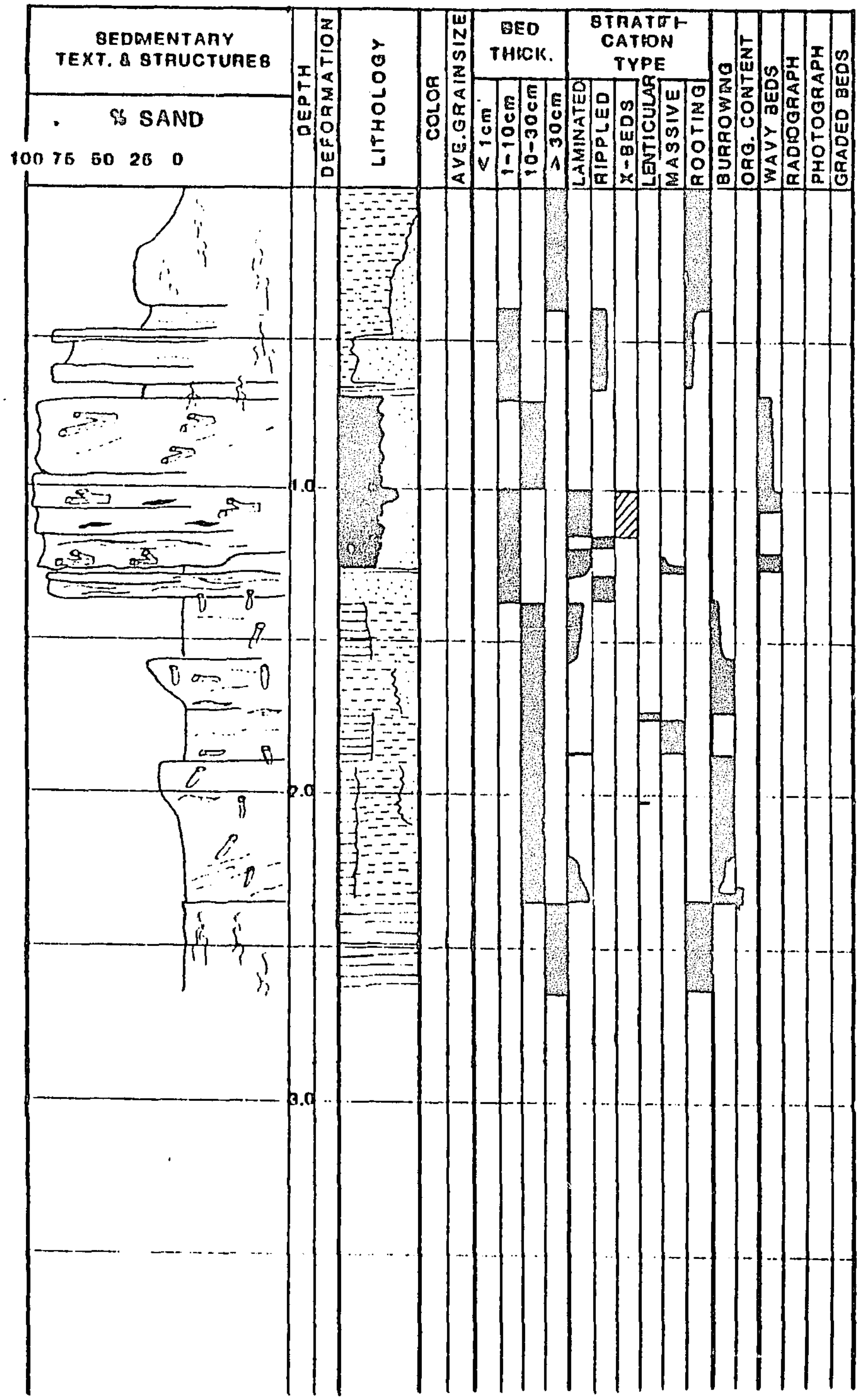
CORE NUMBER FP-44 CORE DEPTH (M) 1.46

LOCATION LAKE FAUSSE POINTE



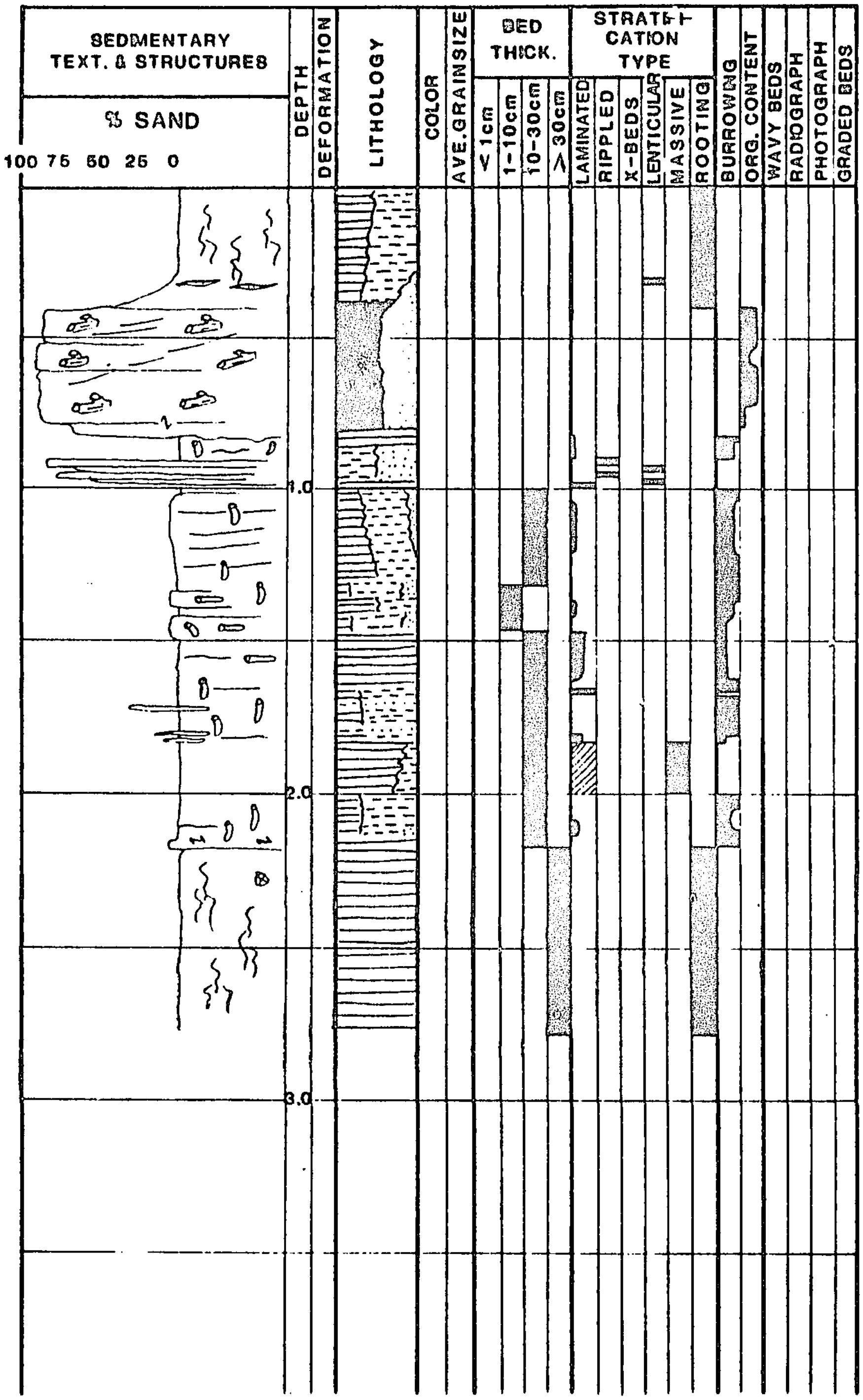
CORE NUMBER FP-45 CORE DEPTH (M) 2.64

LOCATION LAKE FAUSSE POINTE



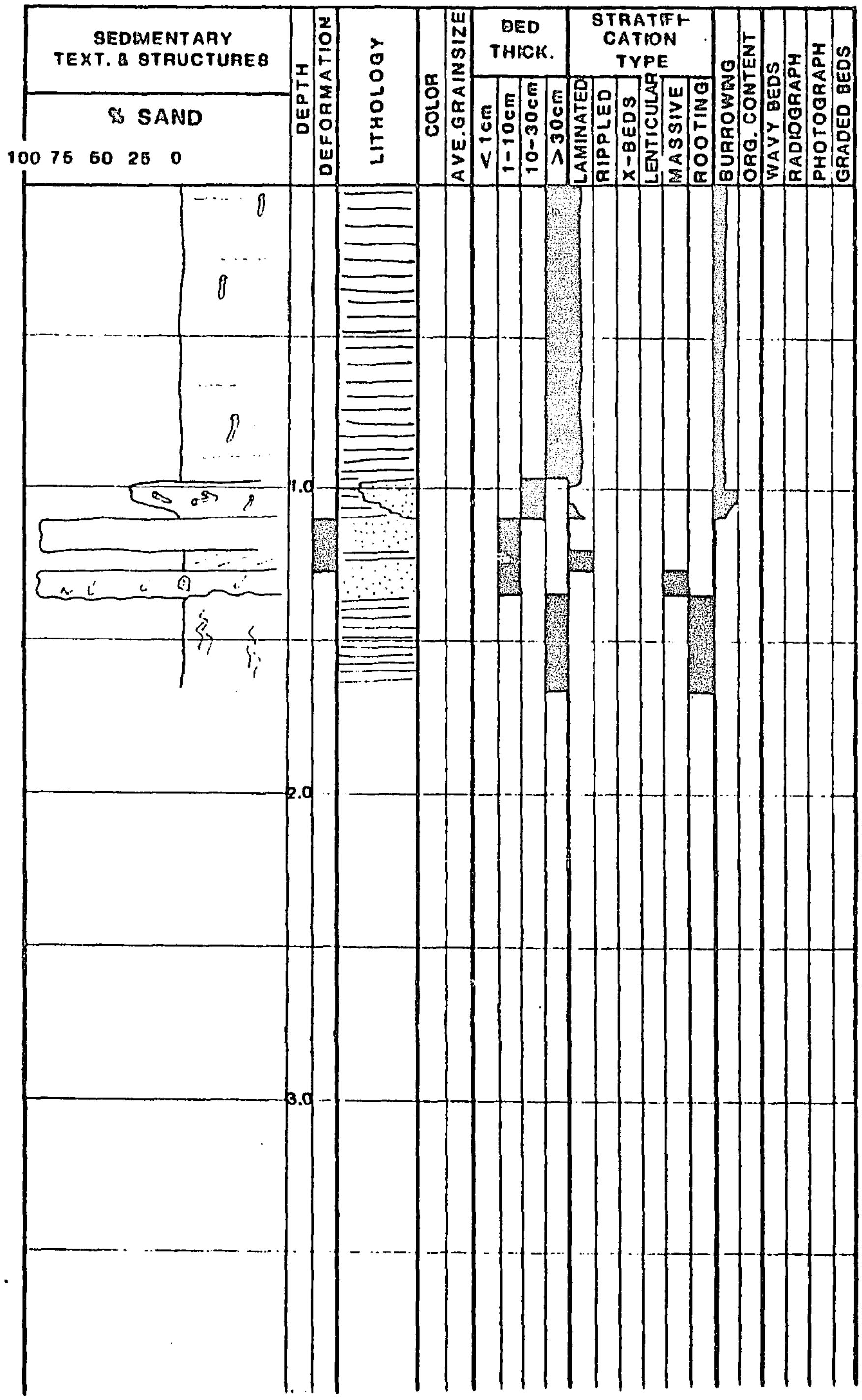
CORE NUMBER FP-46 CORE DEPTH (M) 2.73

LOCATION LAKE FAUSSE POINTE



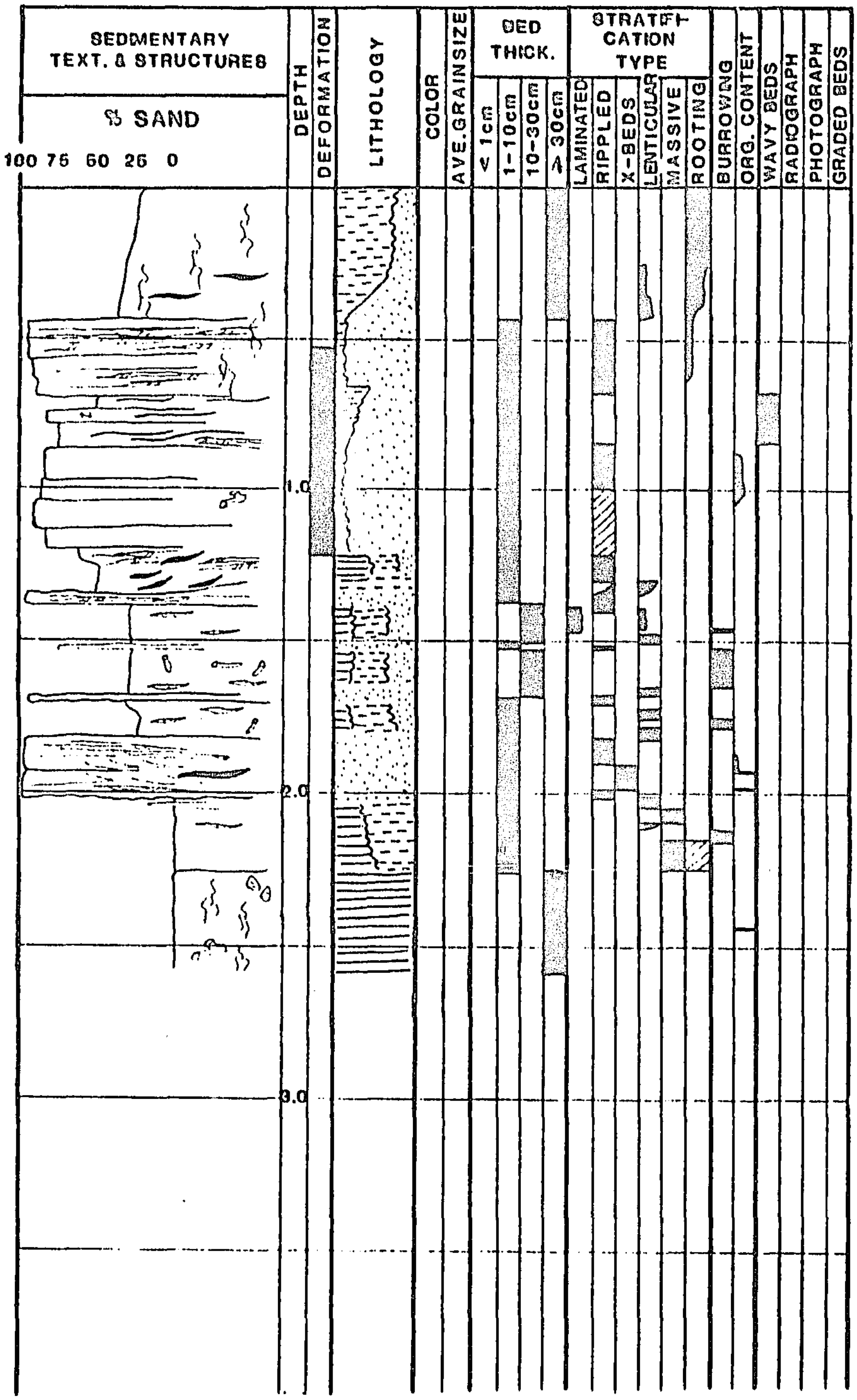
CORE NUMBER FP-47 CORE DEPTH (M) 1.65

LOCATION LAKE FAUSSE POINTE



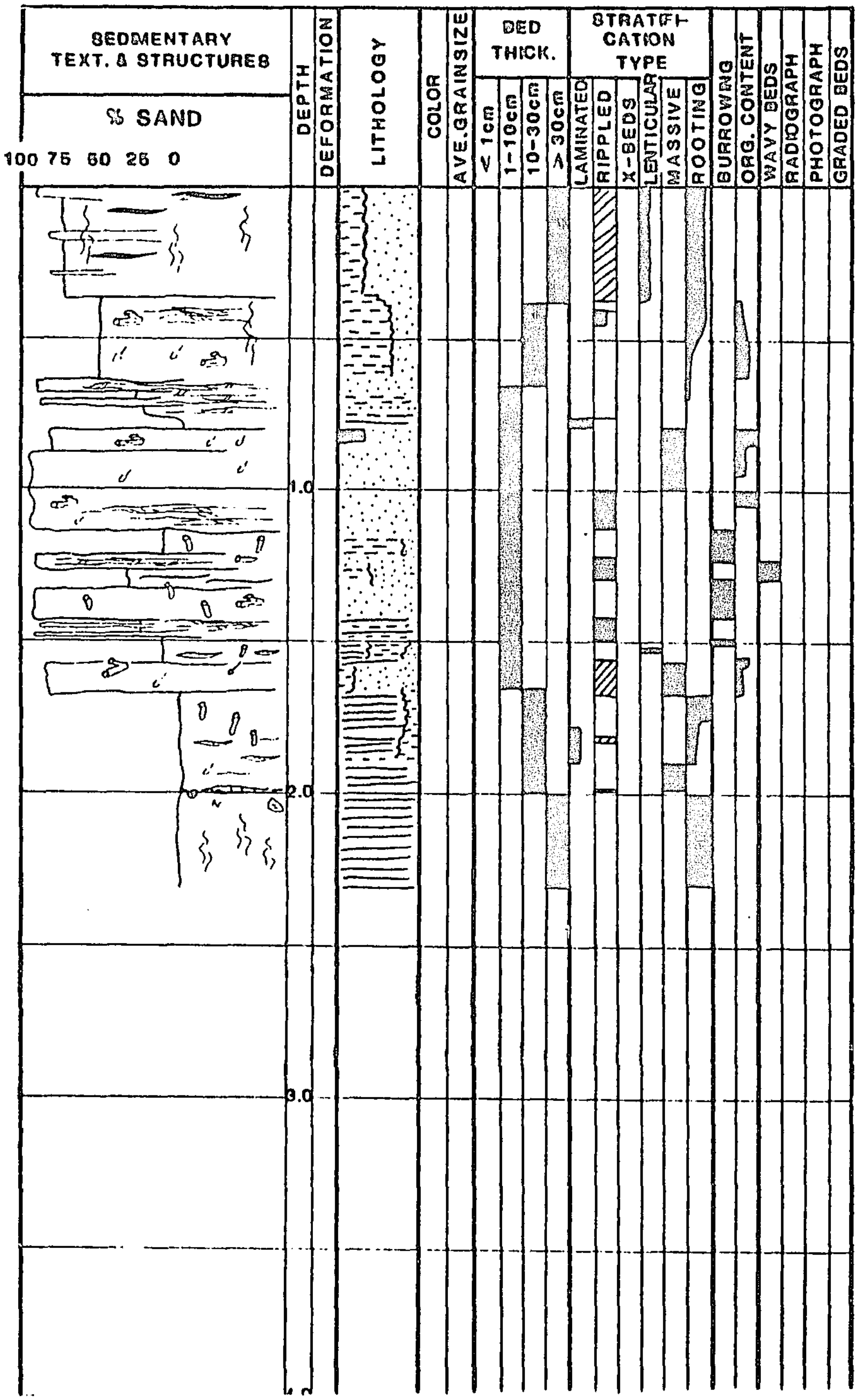
CORE NUMBER FP-48 CORE DEPTH (M) 2.57

LOCATION LAKE FAUSSE POINTE



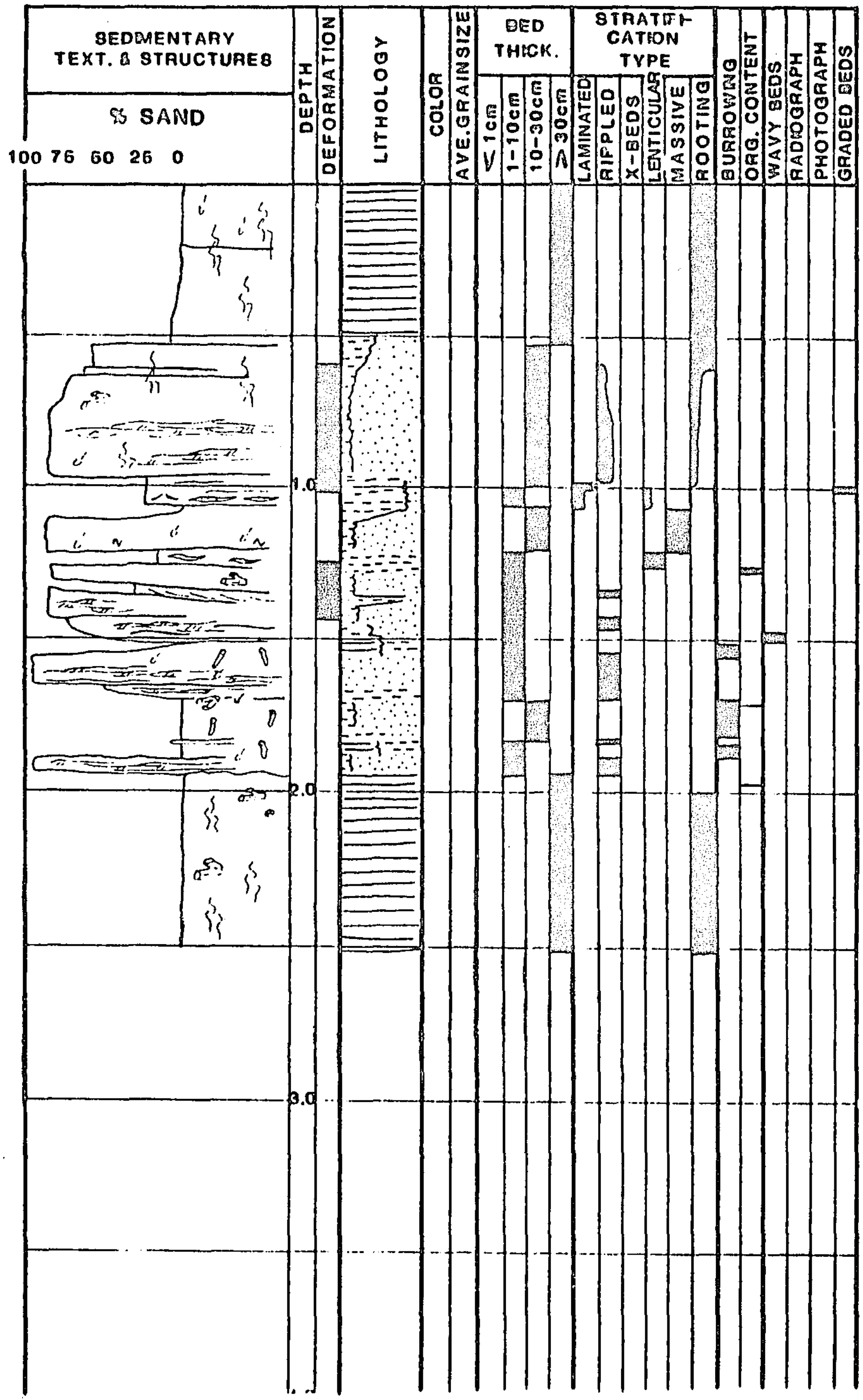
CORE NUMBER FP-49 CORE DEPTH (M) 2.30

LOCATION LAKE FAUSSE POINTE



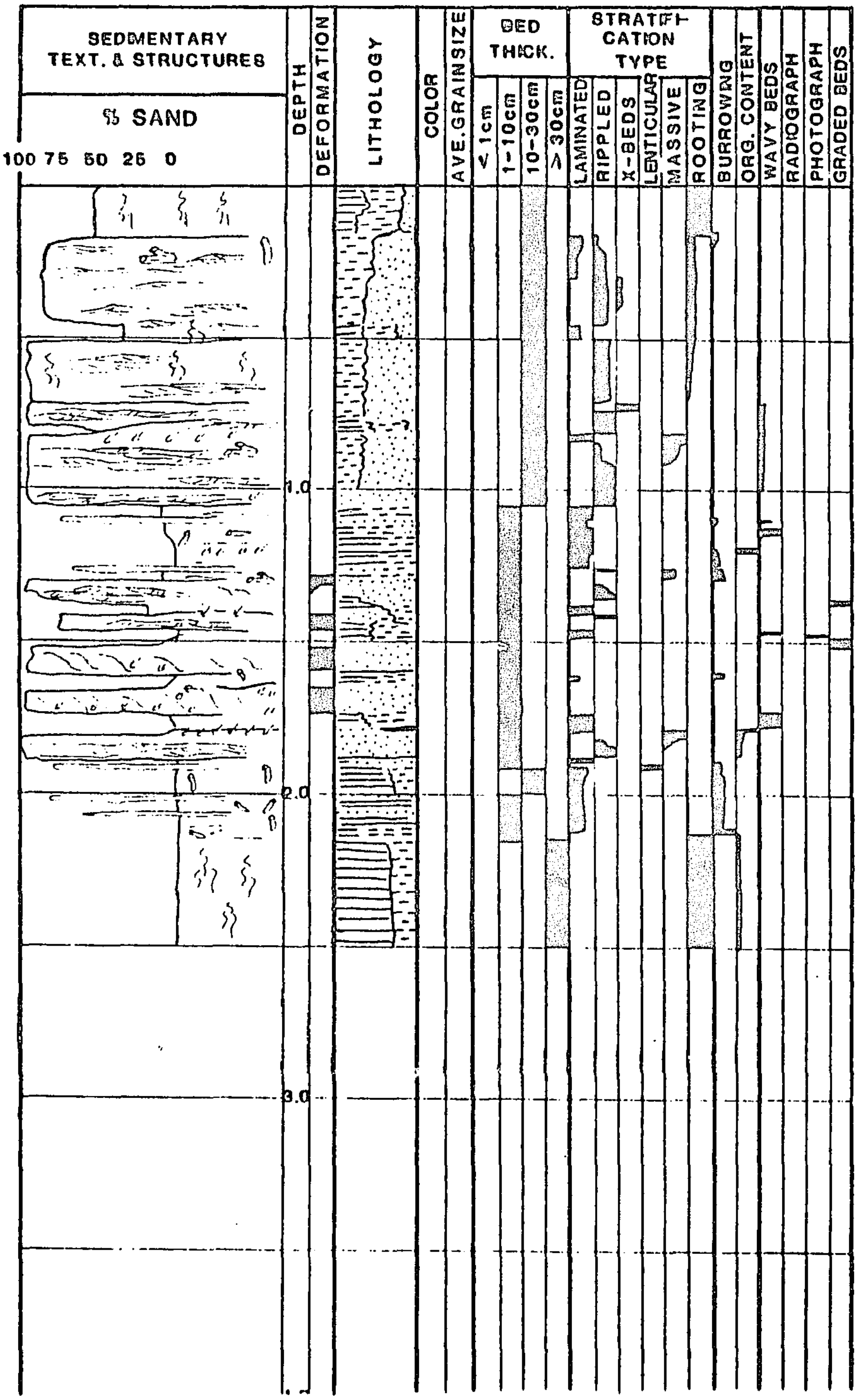
CORE NUMBER FP-50 CORE DEPTH (M) 2.51

LOCATION LAKE FAUSSE POINTE



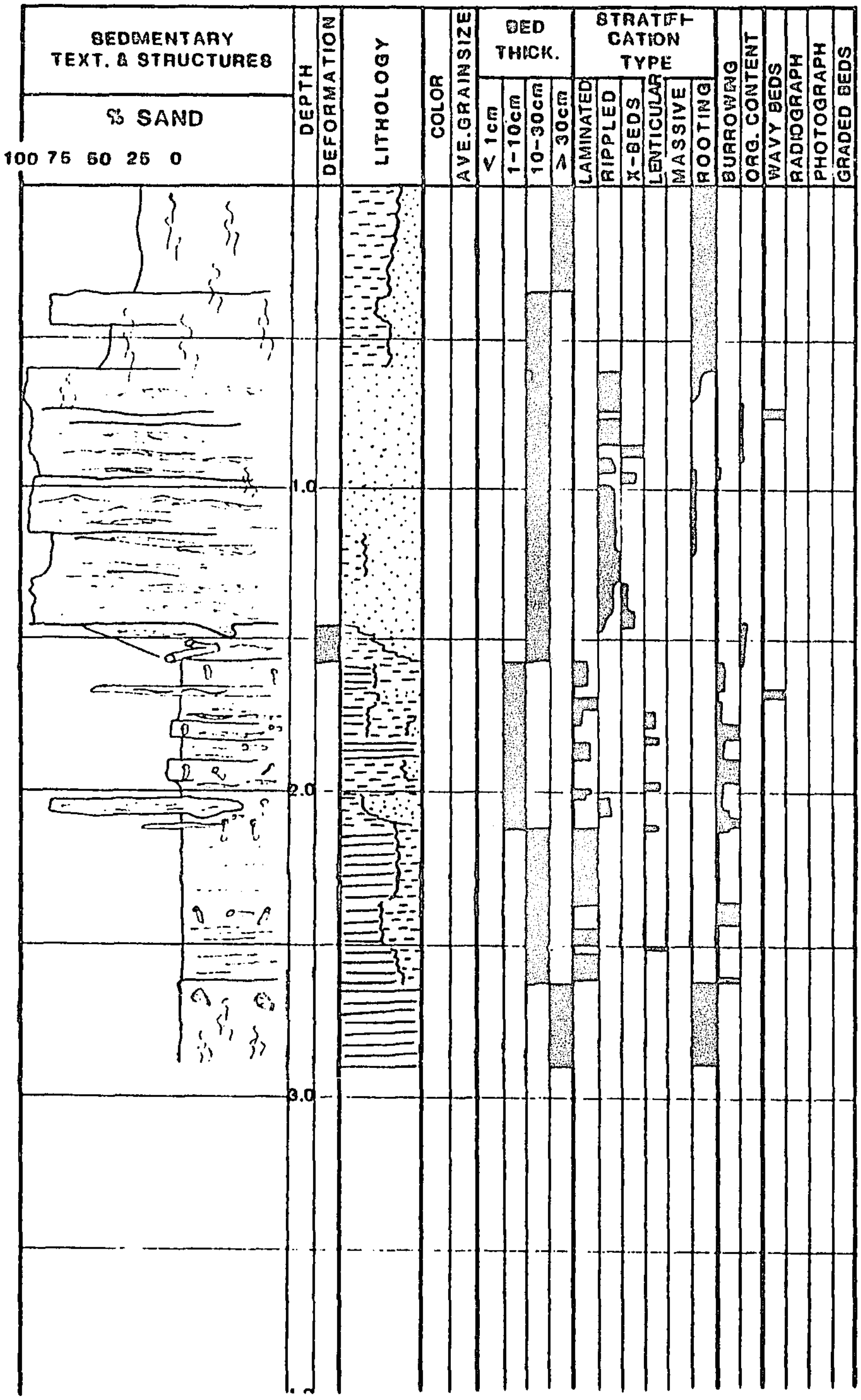
CORE NUMBER FP-51 CORE DEPTH (M) 2.50

LOCATION LAKE FAUSSE POINTE



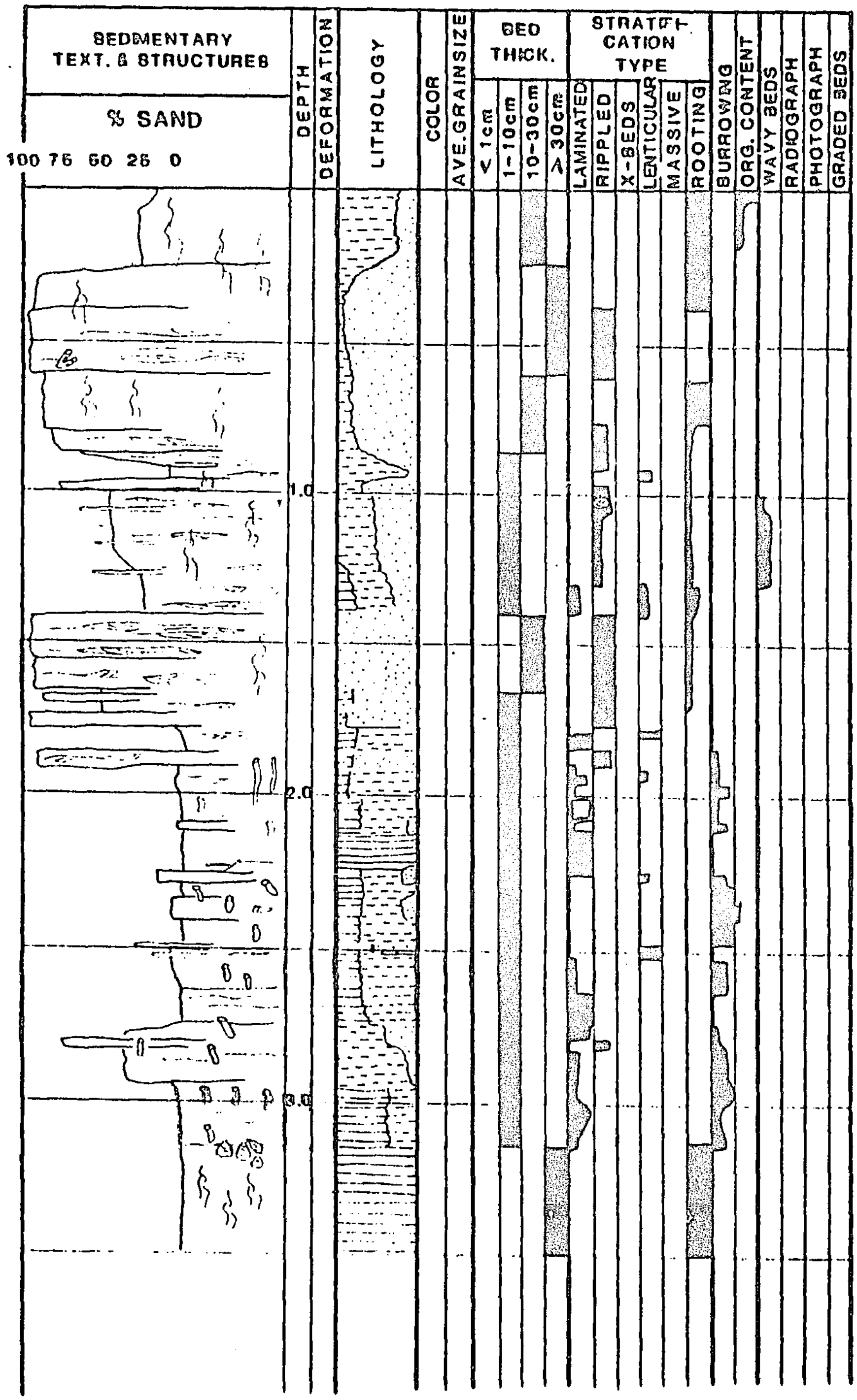
CORE NUMBER *FP-52* CORE DEPTH (M) *2.90*

LOCATION LAKE FAUSSE POINTE



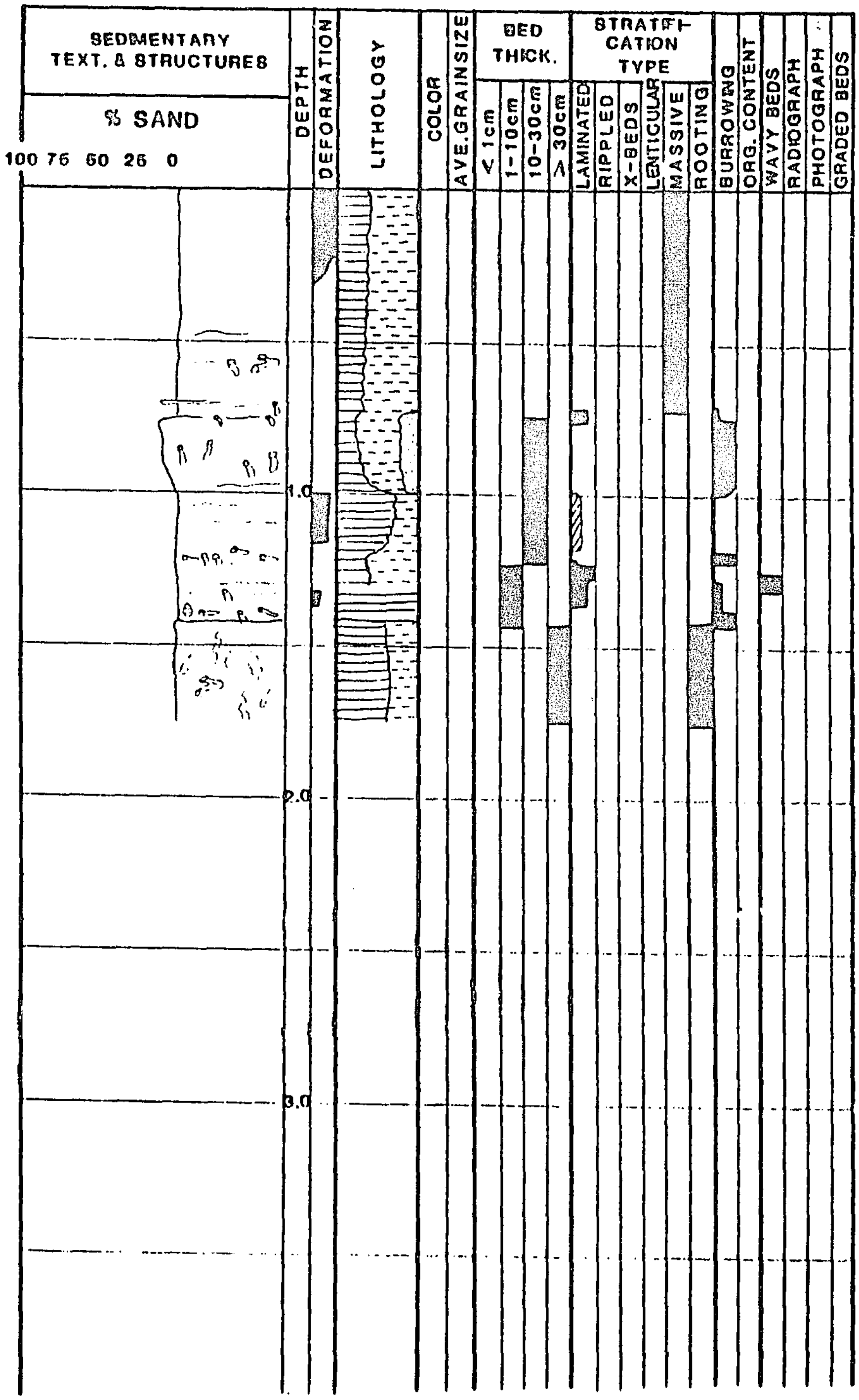
CORE NUMBER FP-53 CORE DEPTH (M) 3.50

LOCATION LAKE FAUSSE POINTE



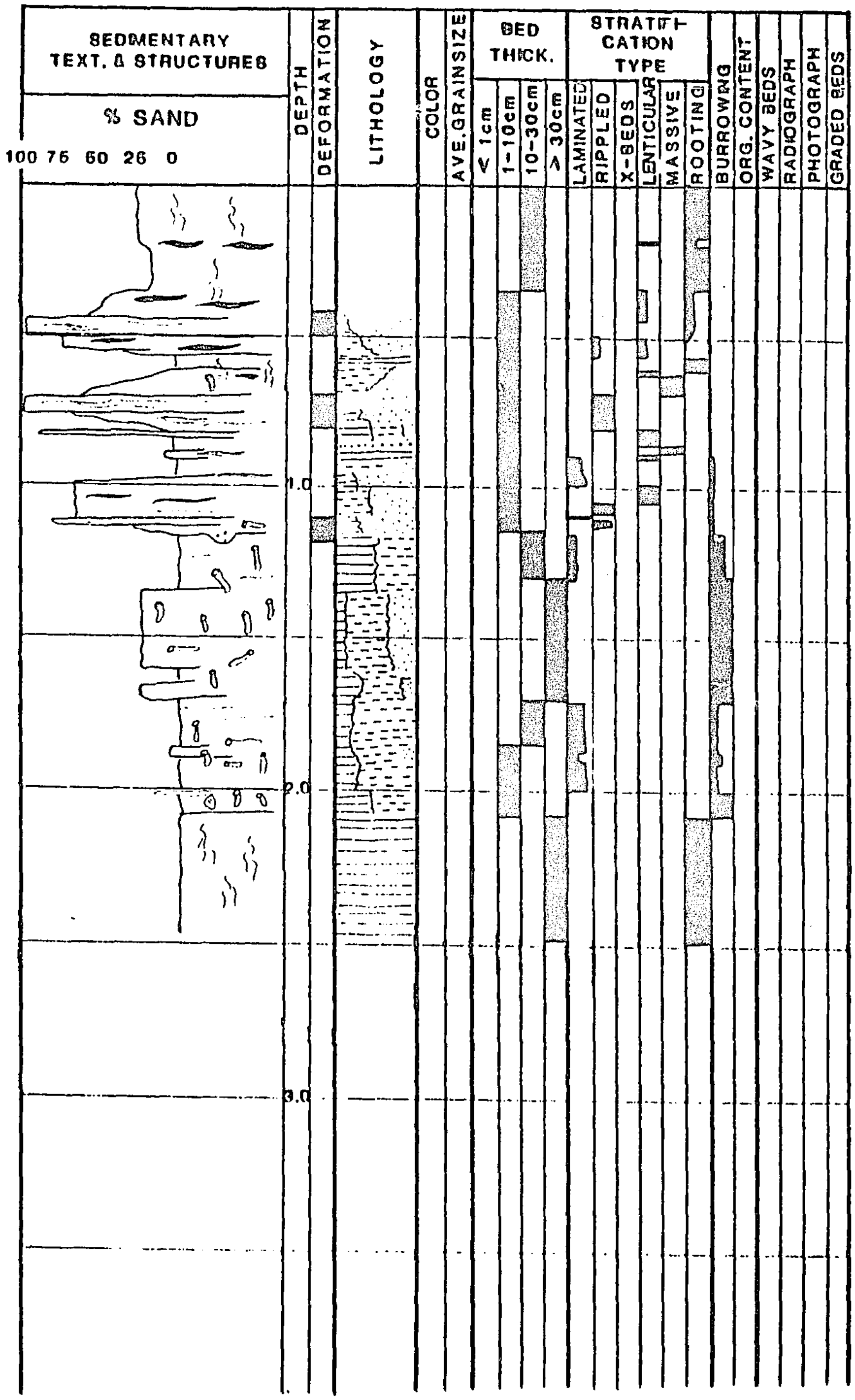
CORE NUMBER FP-54 CORE DEPTH (M) 1.75

LOCATION LAKE FAUSSE POINTE



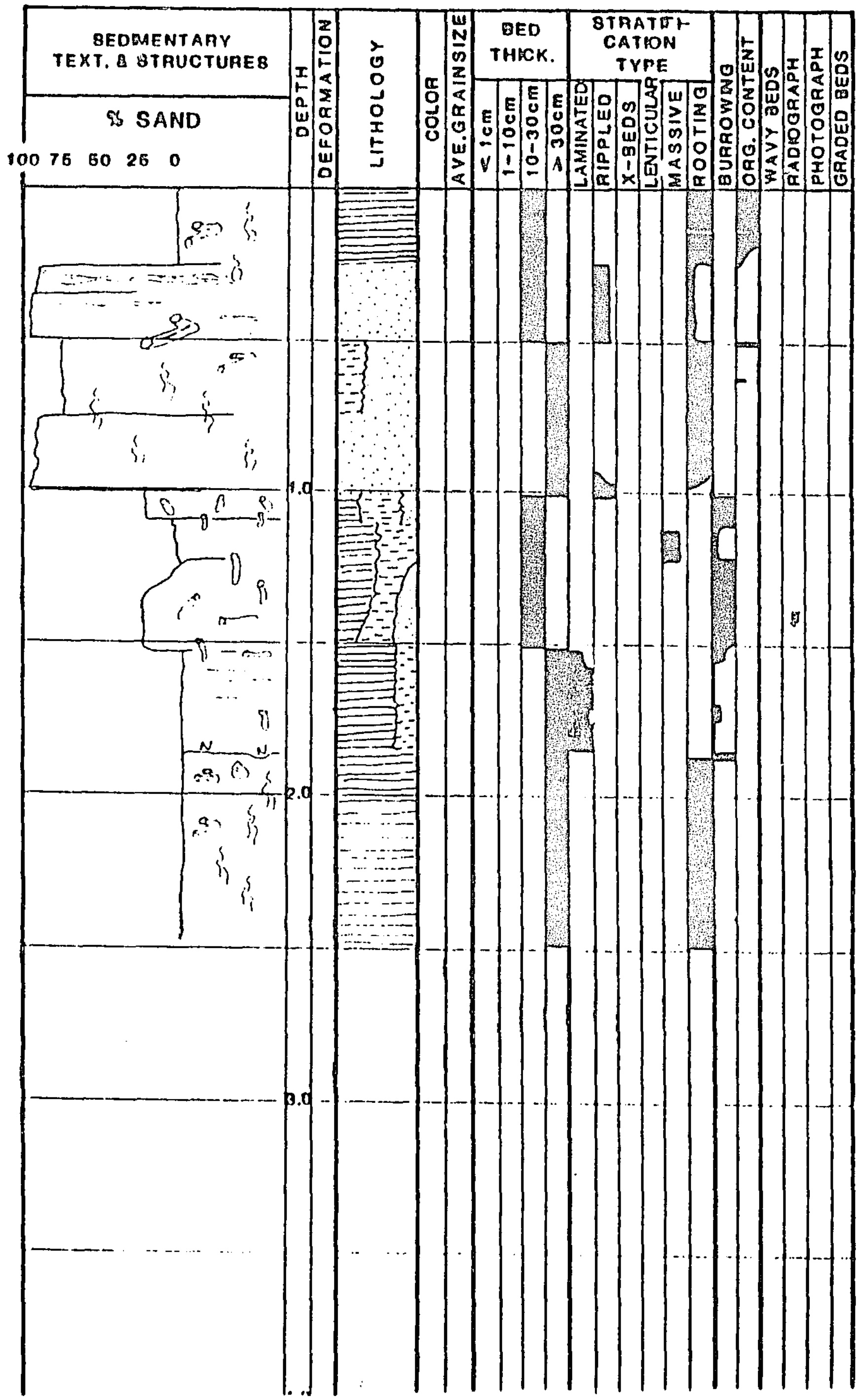
CORE NUMBER EP-55 CORE DEPTH (M) 2.47

LOCATION LAKE FAUSSE POINTE



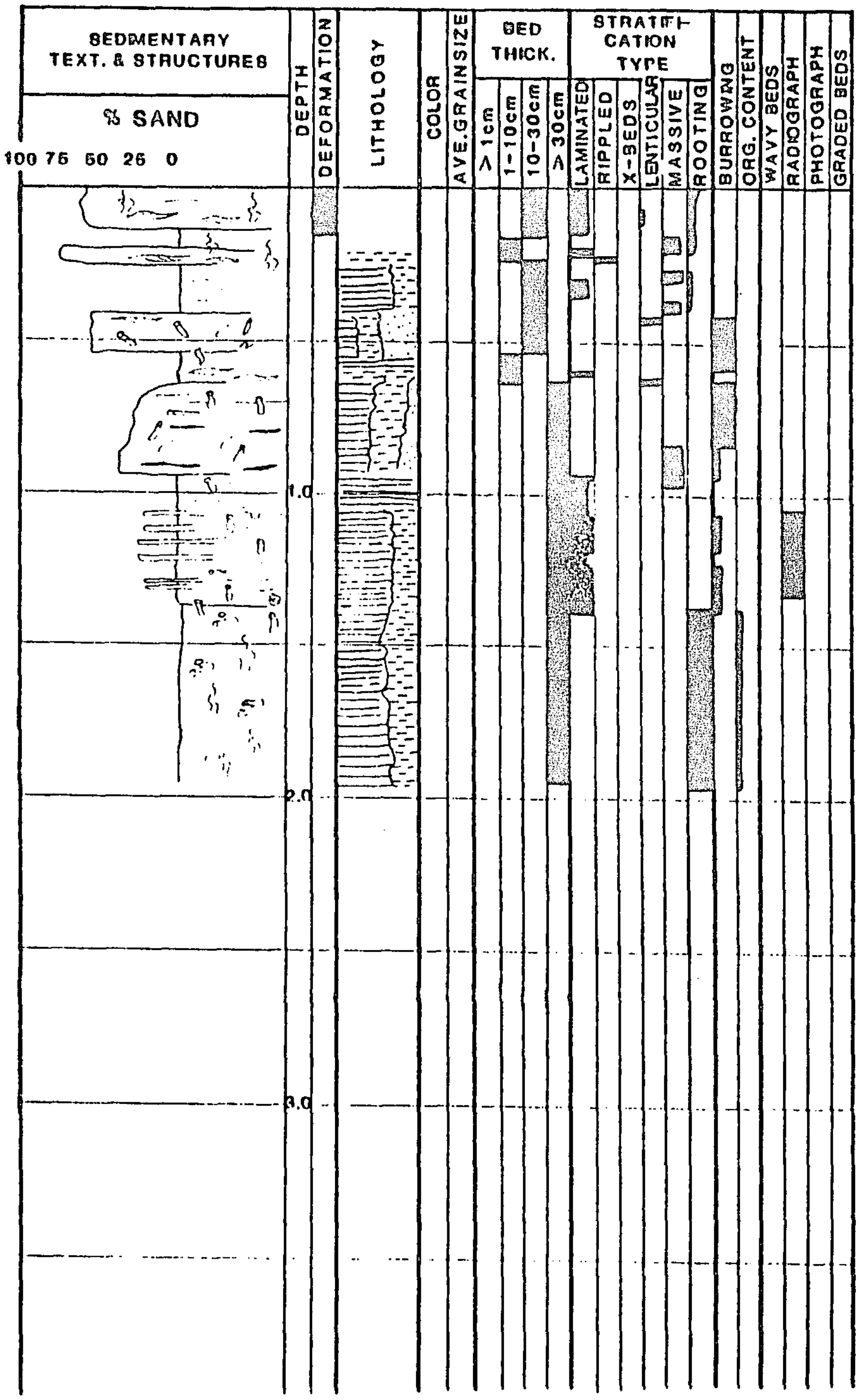
CORE NUMBER FP-56 CORE DEPTH (M) 2.48

LOCATION LAKE FAUSSE POINTE



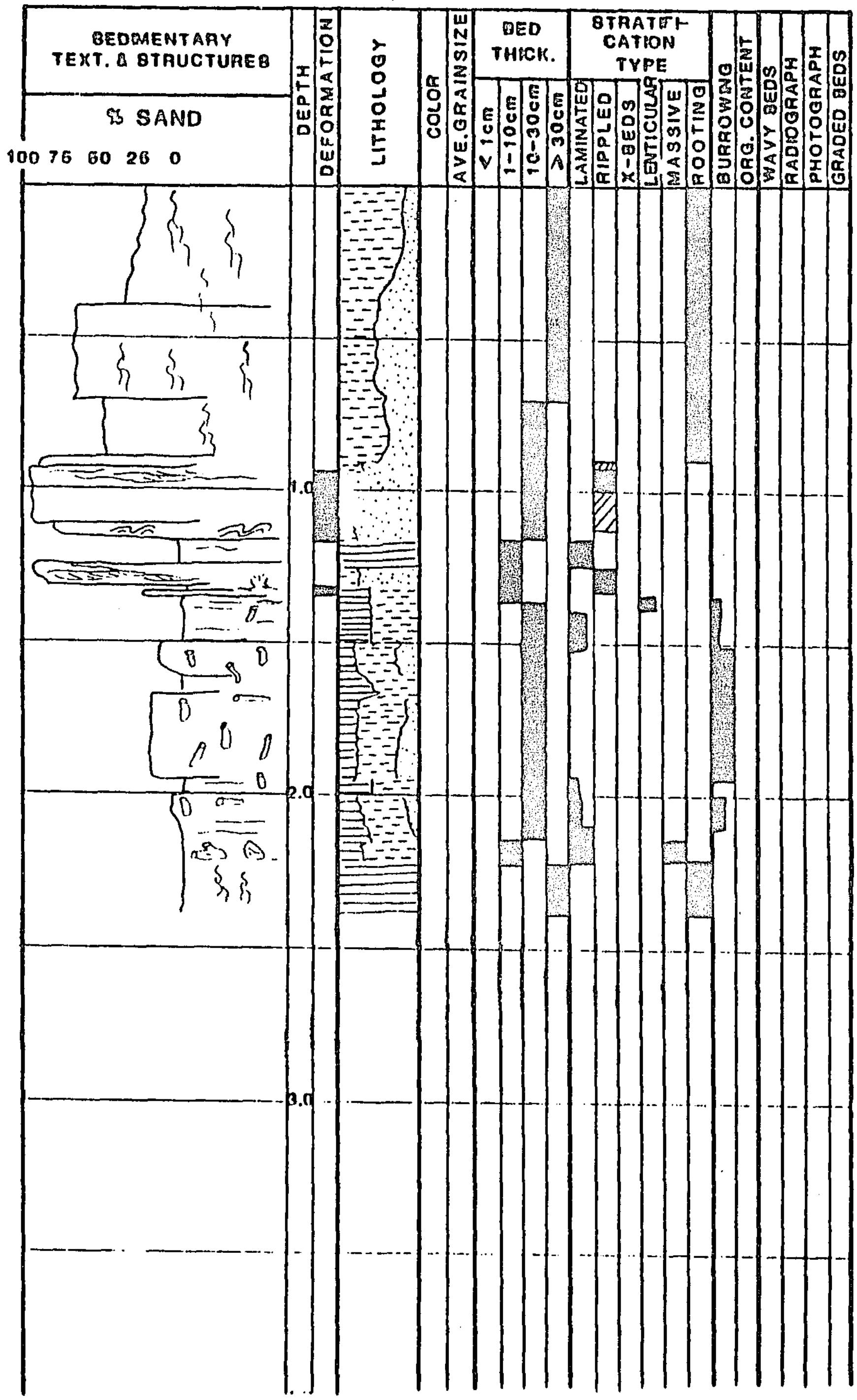
CORE NUMBER FP-57 CORE DEPTH (M) 1.06

LOCATION LAKE FAUSSE POINTE



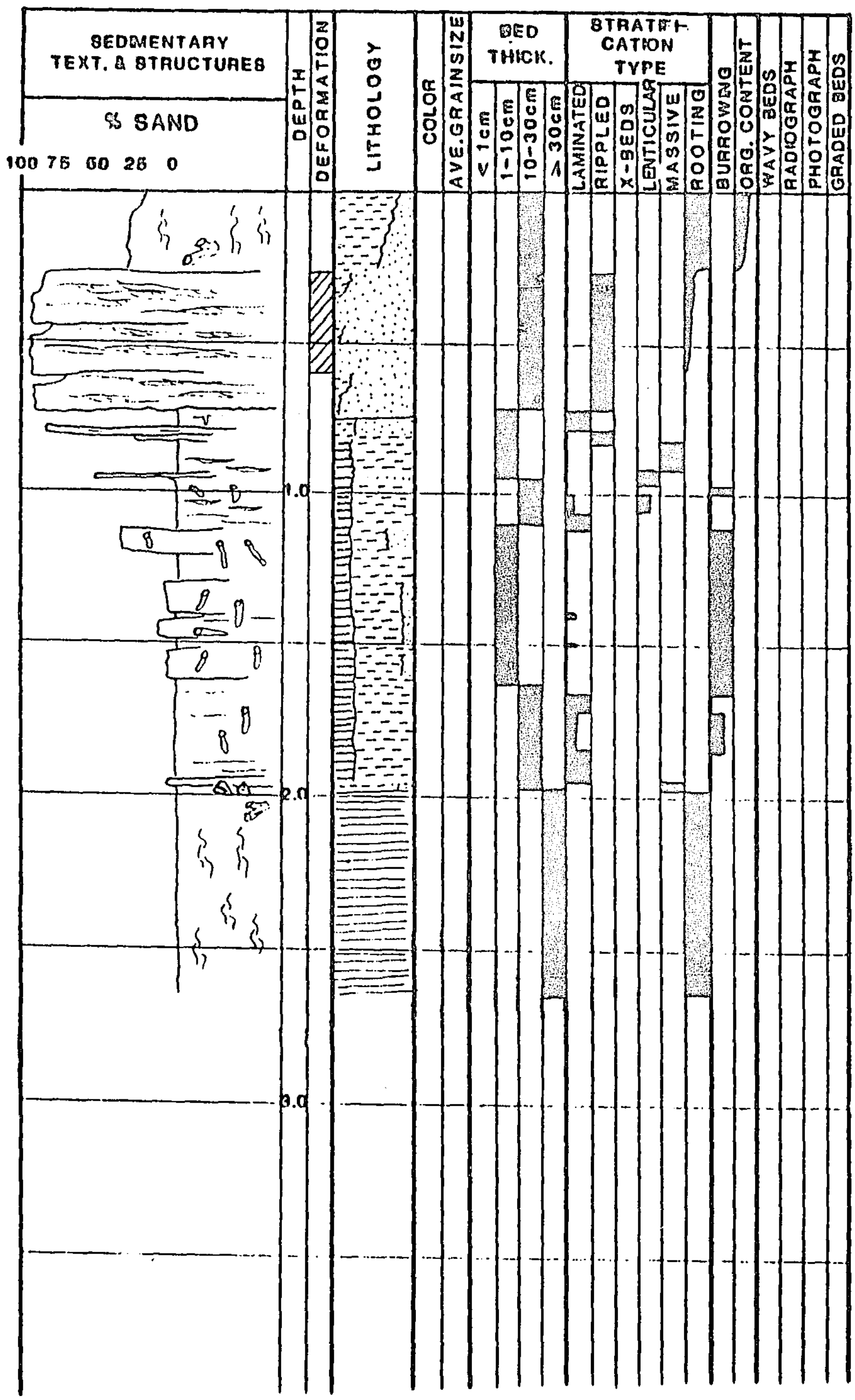
CORE NUMBER FP-58 CORE DEPTH (M) 2.38

LOCATION LAKE FAUSSE POINTE



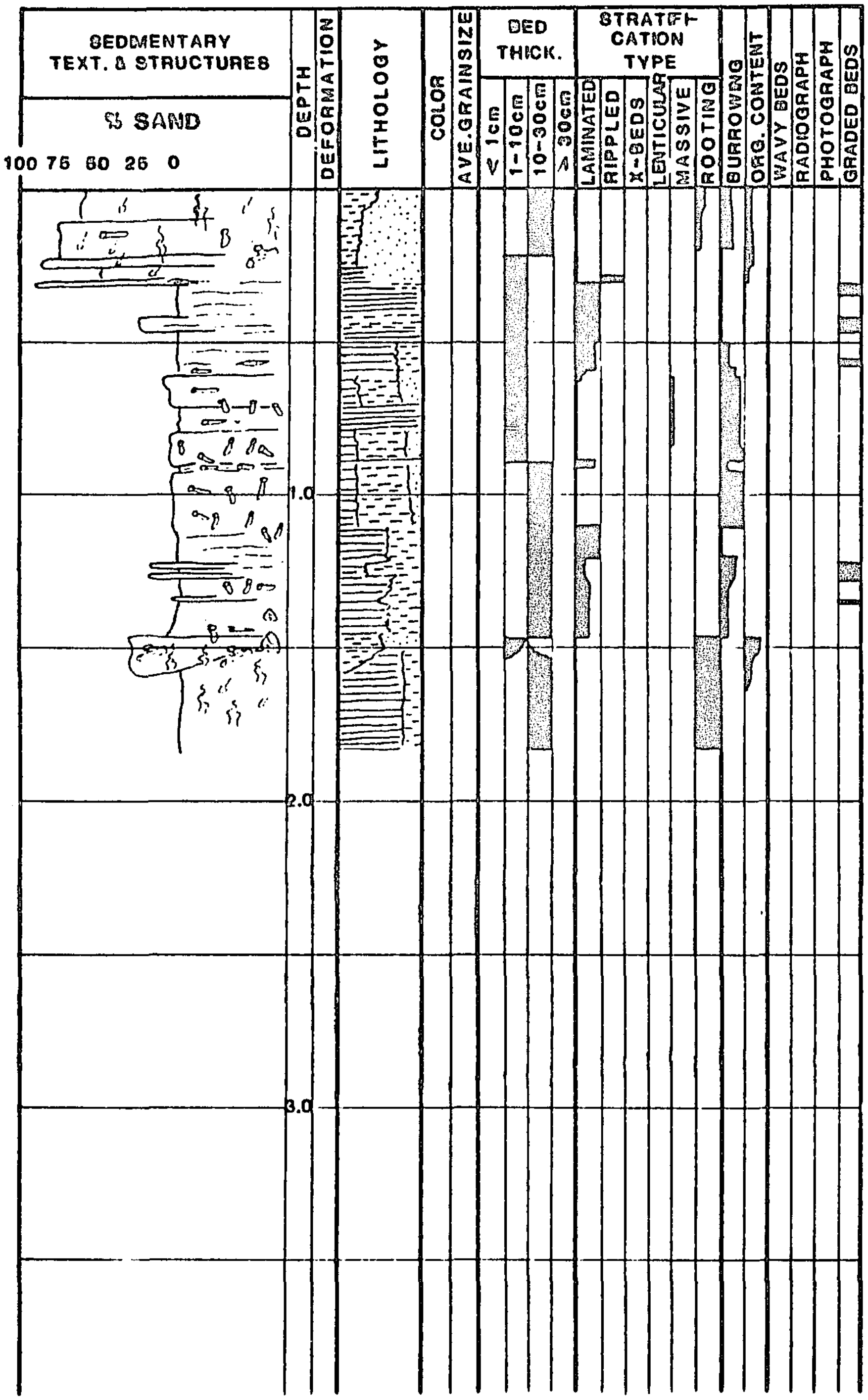
CORE NUMBER FP-59 CORE DEPTH (M) 2.64

LOCATION LAKE FAUSSE POINTE



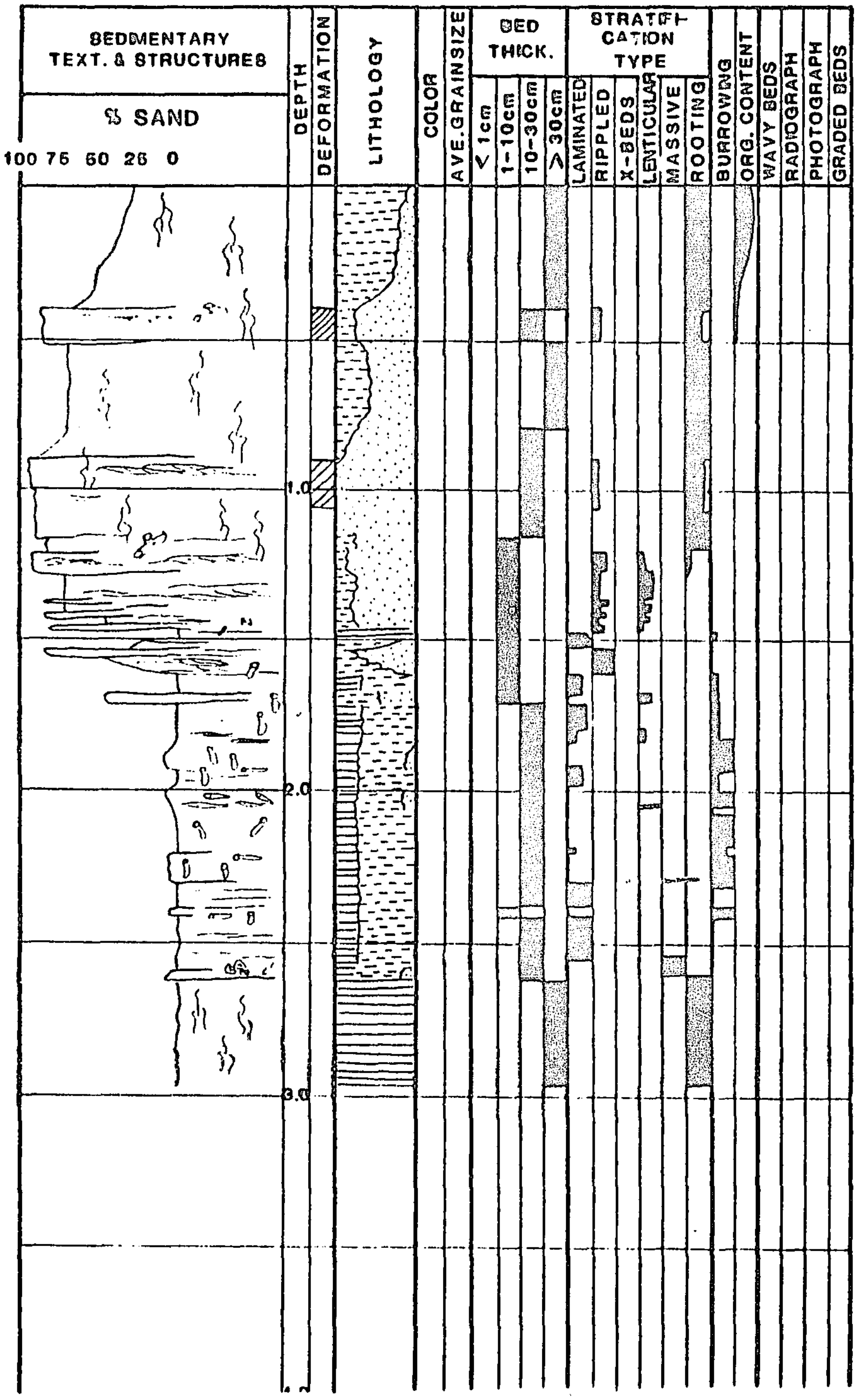
CORE NUMBER FP-60　　CORE DEPTH (M) 1.79

LOCATION LAKE FAUSSE POINTE



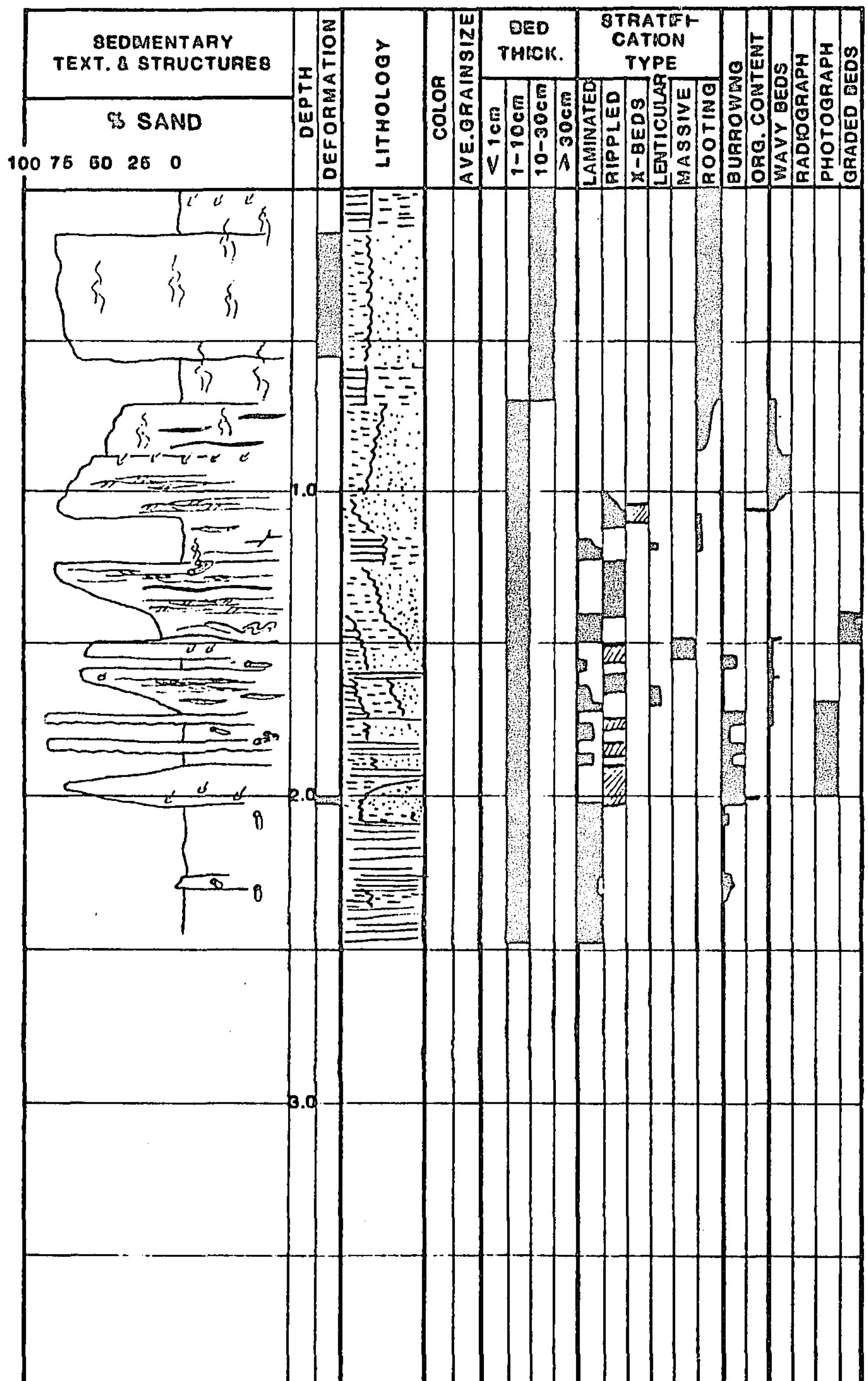
CORE NUMBER FP-61 CORE DEPTH (M) 2.96

LOCATION LAKE FAUSSE POINTE



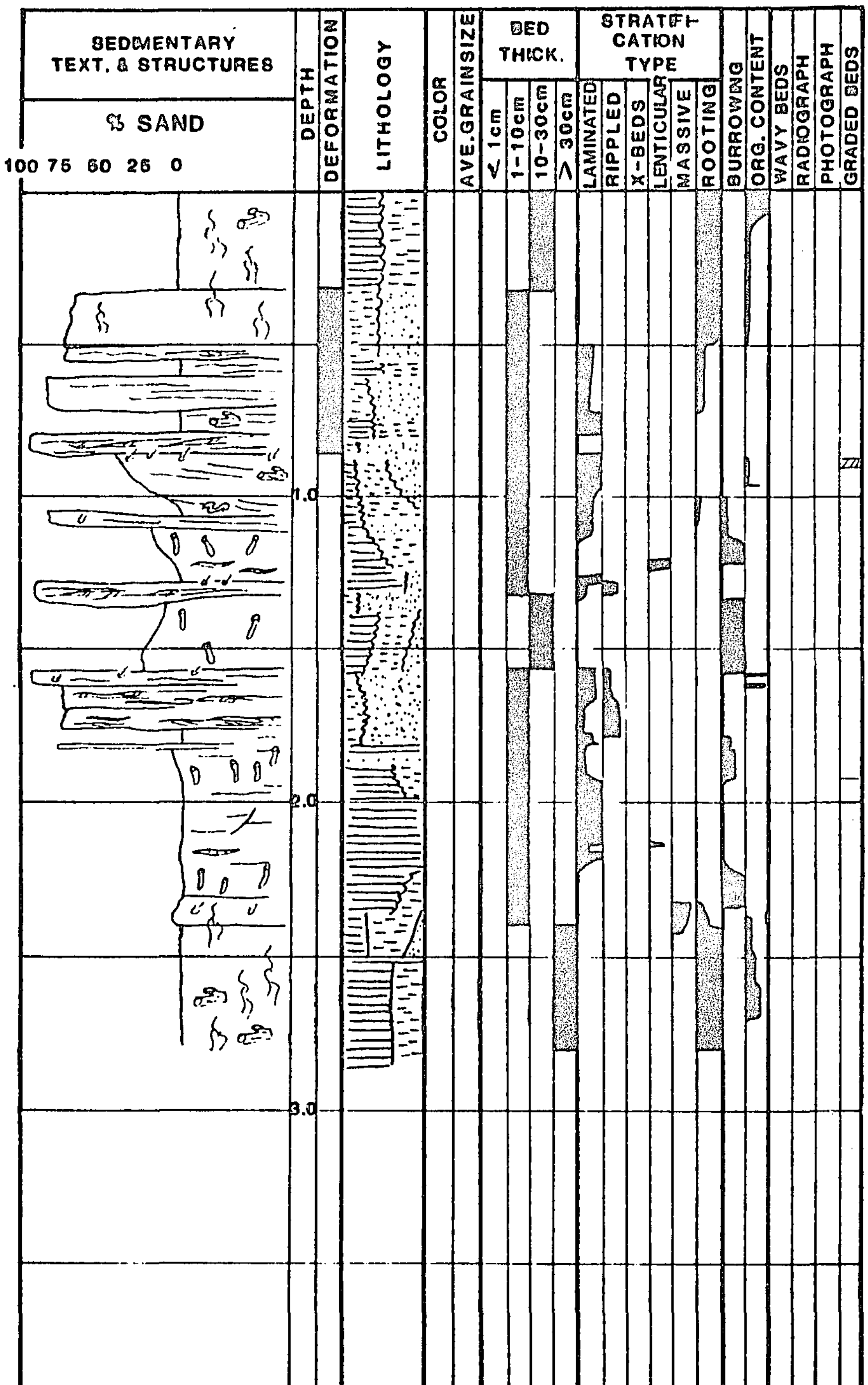
CORE NUMBER FP-62 CORE DEPTH (M) 2.47

LOCATION LAKE FAUSSE POINTE



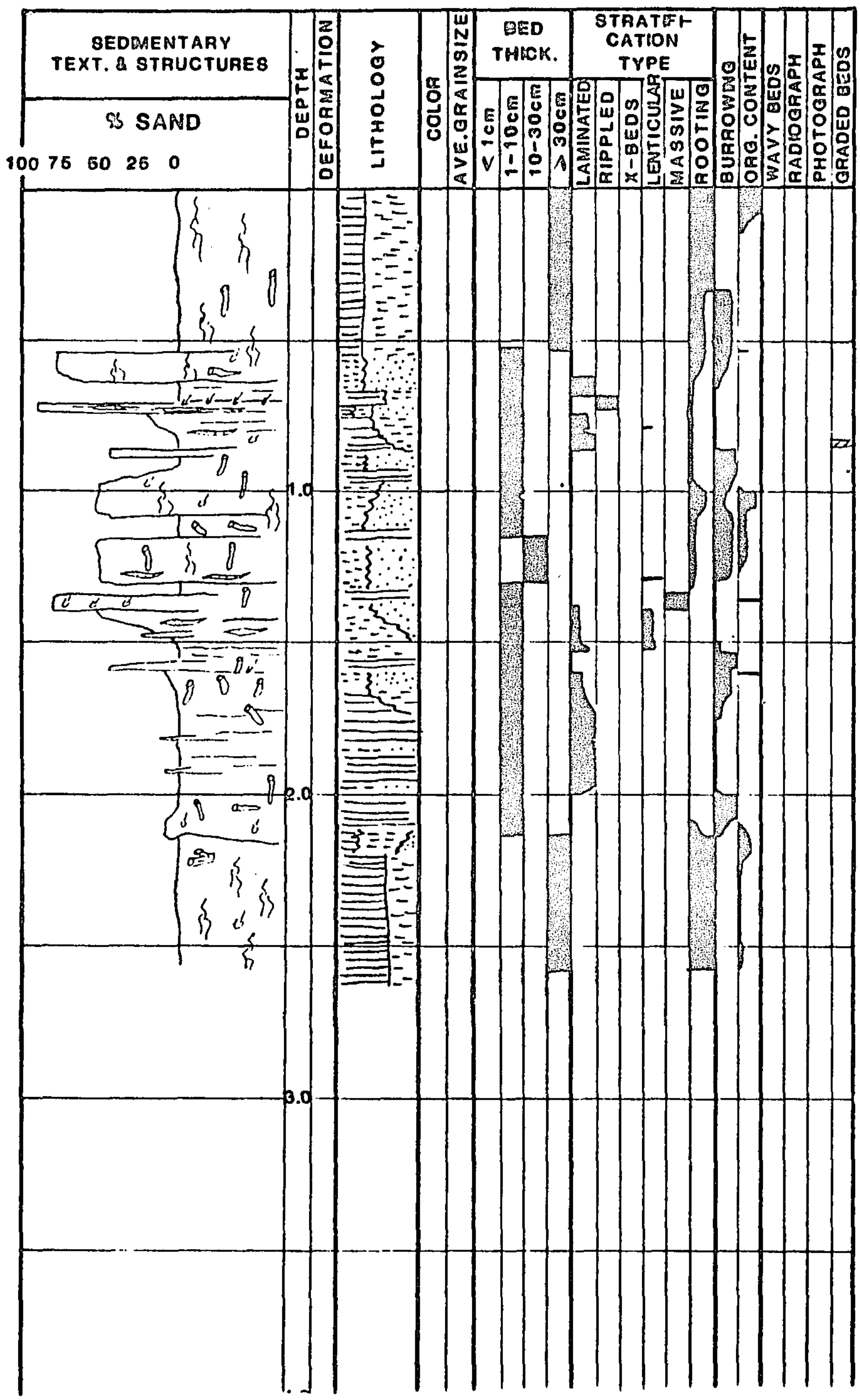
CORE NUMBER FP-63 CORE DEPTH (M) 2.74

LOCATION LAKE FAUSSE POINTE



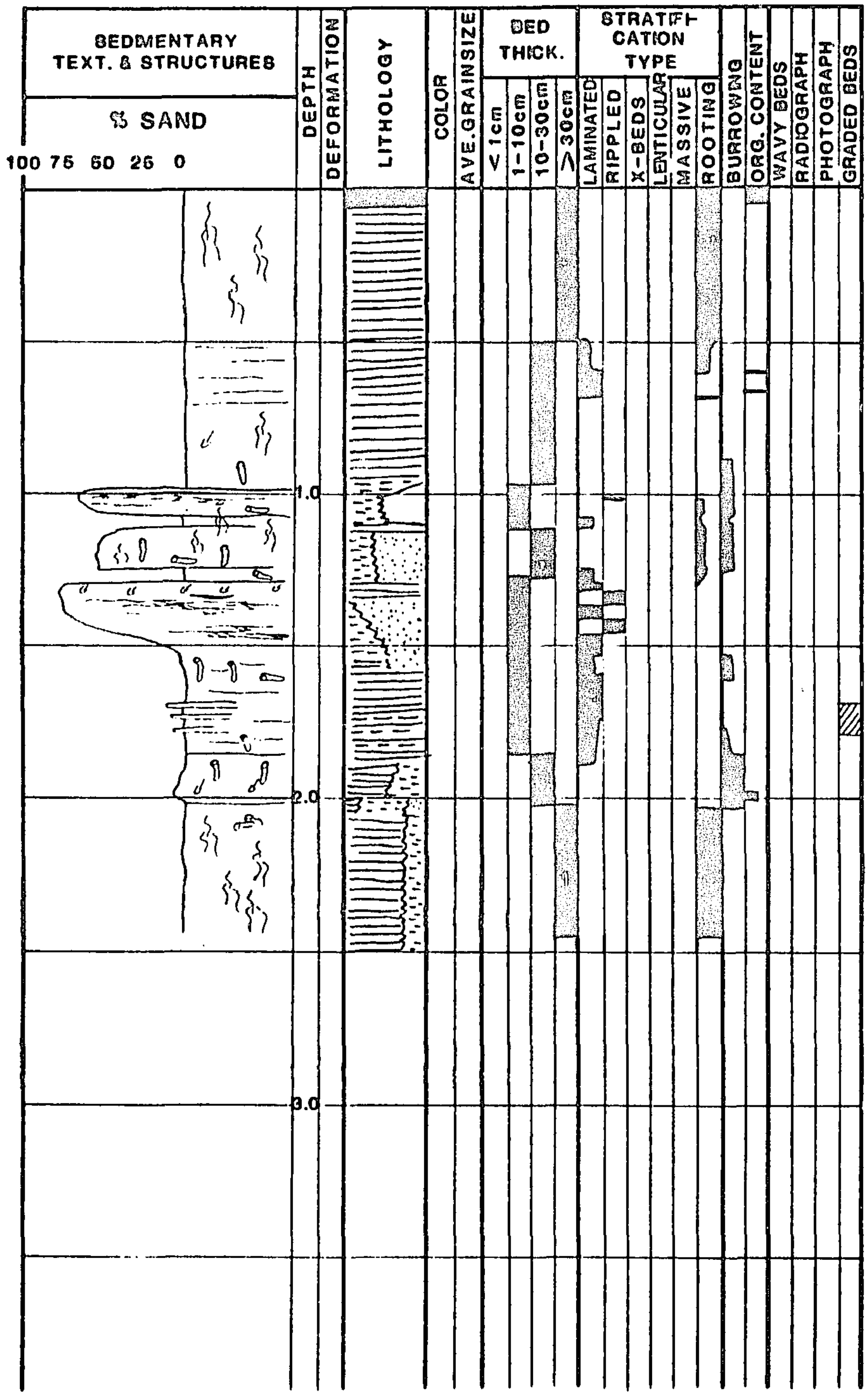
CORE NUMBER FP-64 CORE DEPTH (M) 2.58

LOCATION LAKE FAUSSE POINTE



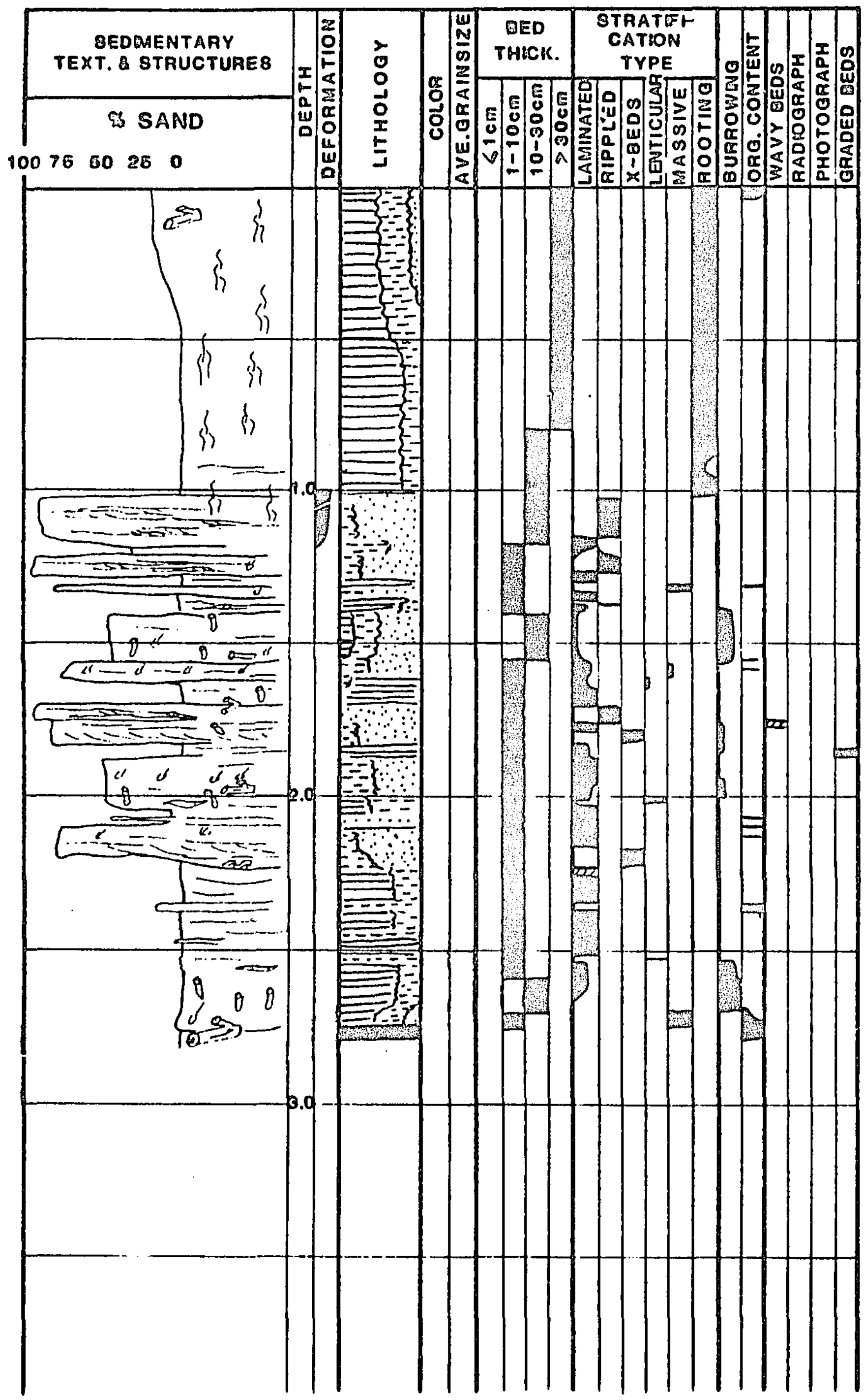
CORE NUMBER FP-65 CORE DEPTH (M) 2.44

LOCATION LAKE FAUSSE POINTE



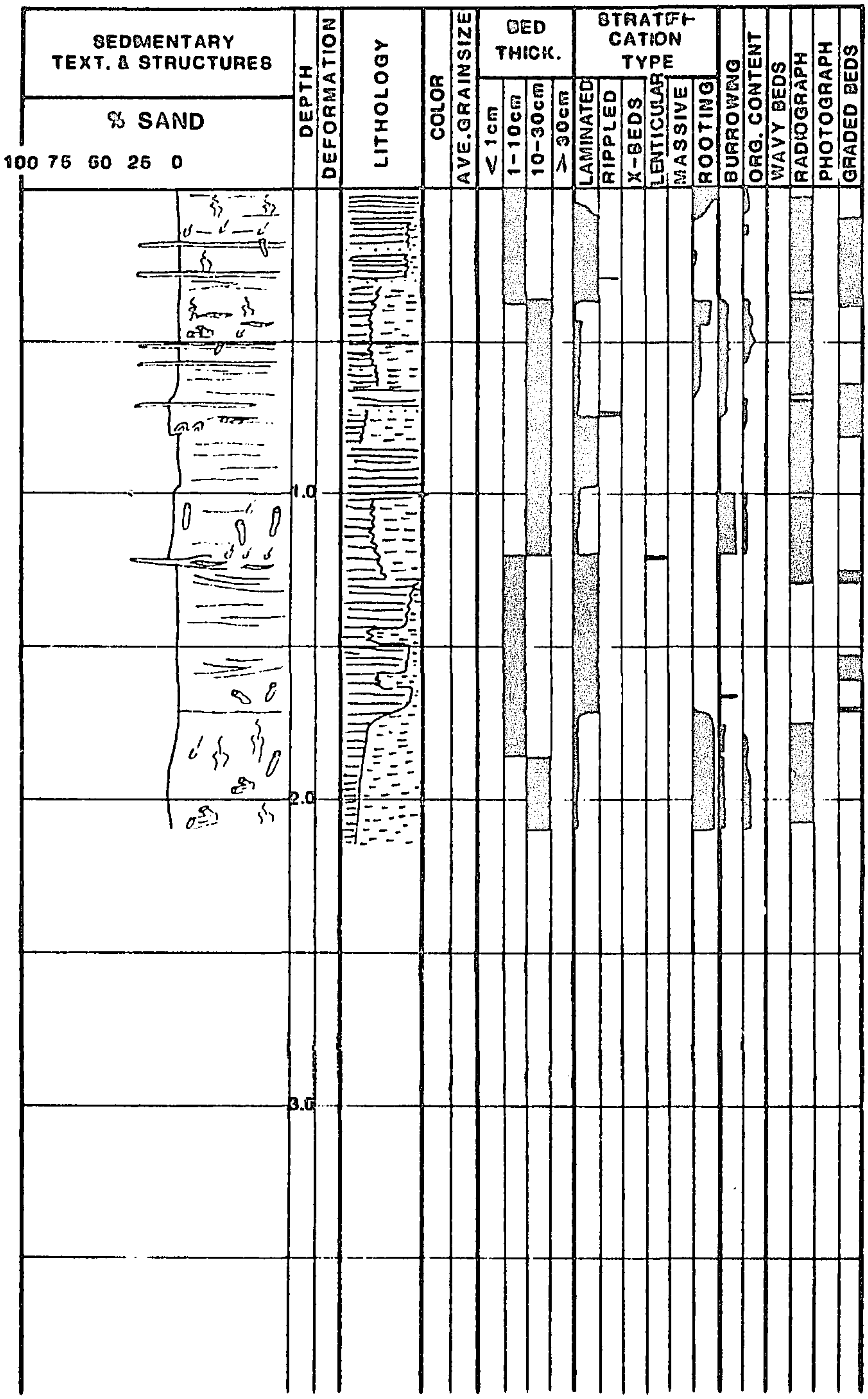
CORE NUMBER FP-66 CORE DEPTH (M) 2.70

LOCATION LAKE FAUSSE POINTE



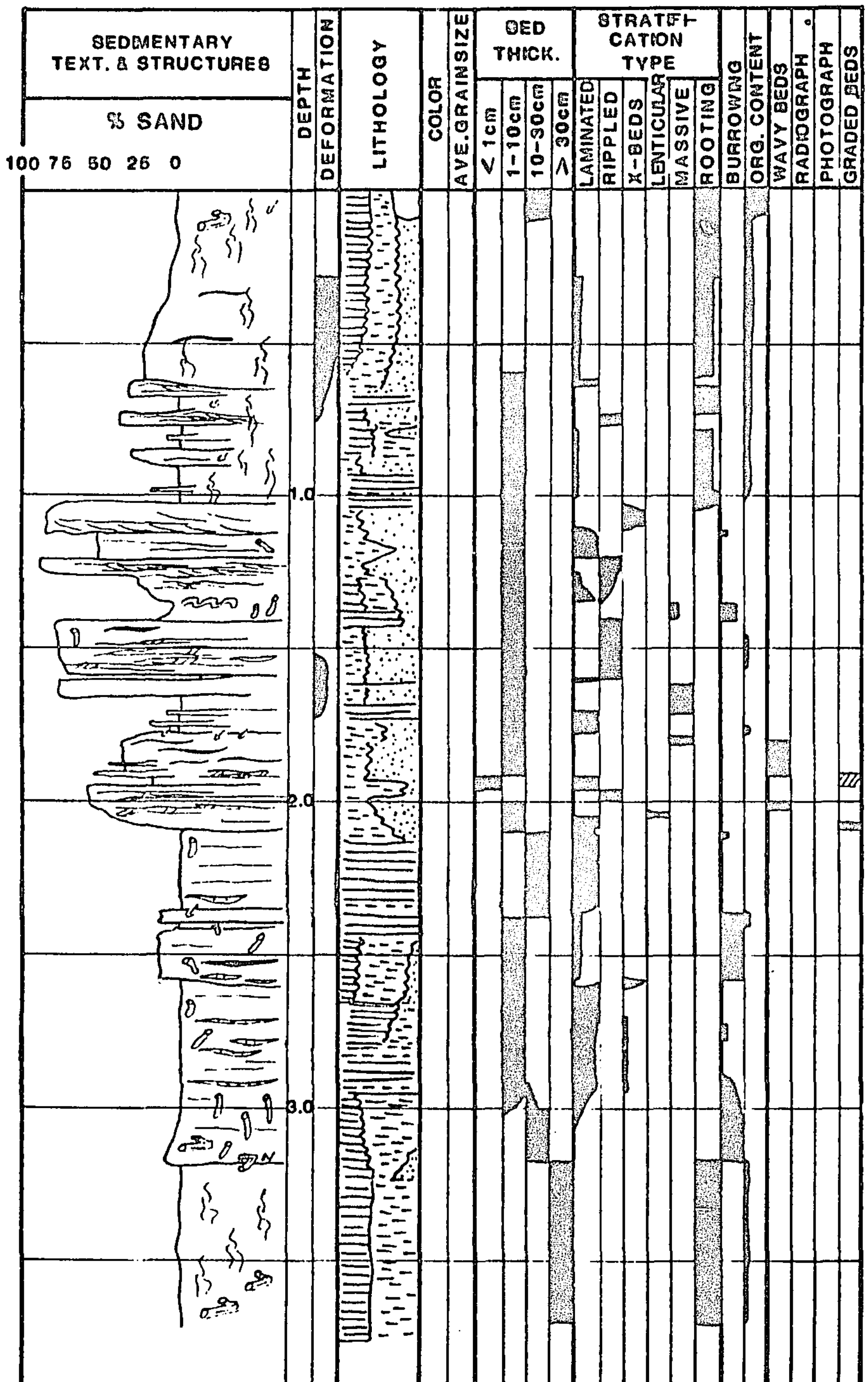
CORE NUMBER FP-67 CORE DEPTH (M) 2.07

LOCATION LAKE FAUSSE POINTE



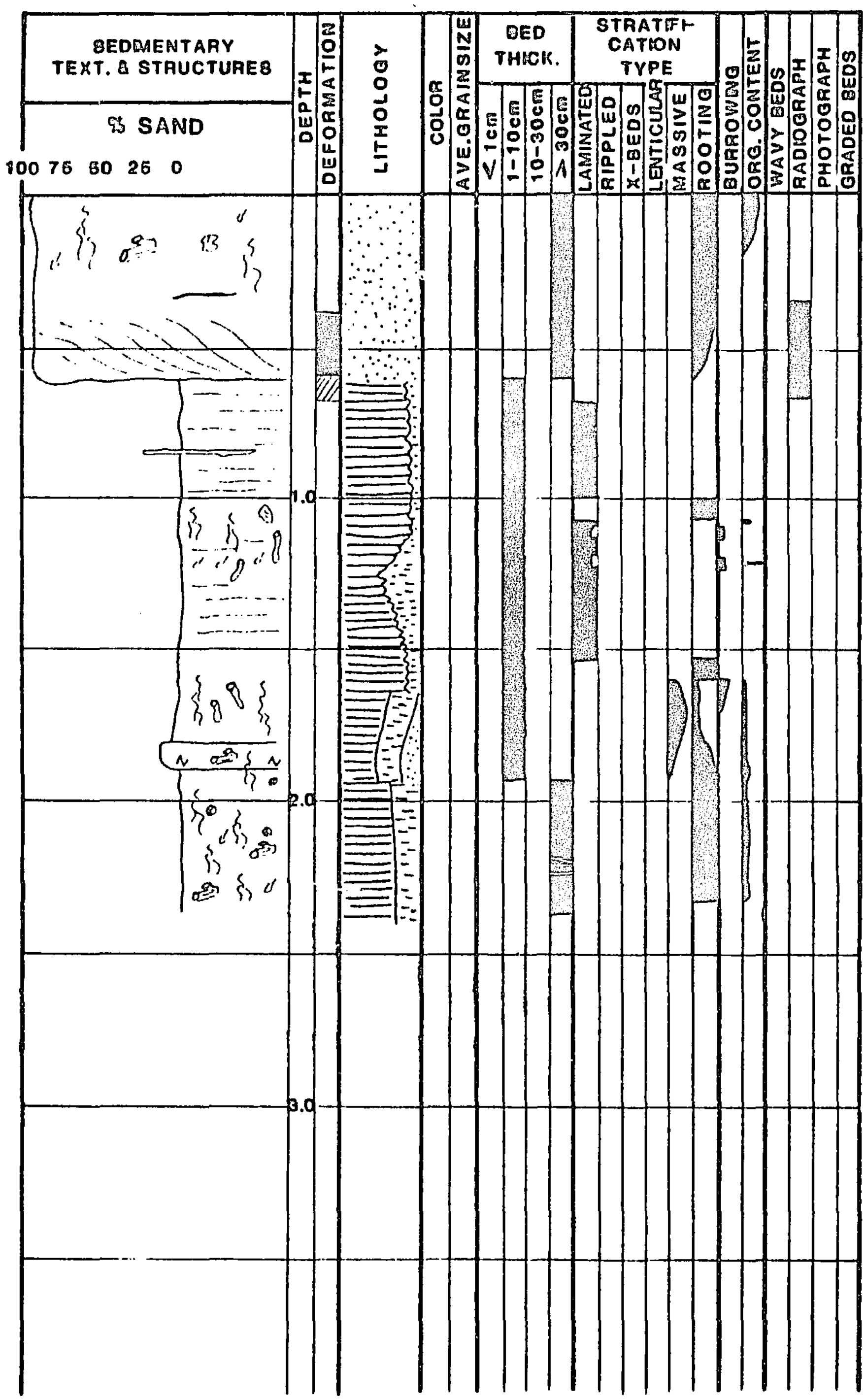
CORE NUMBER FP-70 CORE DEPTH (M) 3.71

LOCATION LAKE FAUSSE POINTE



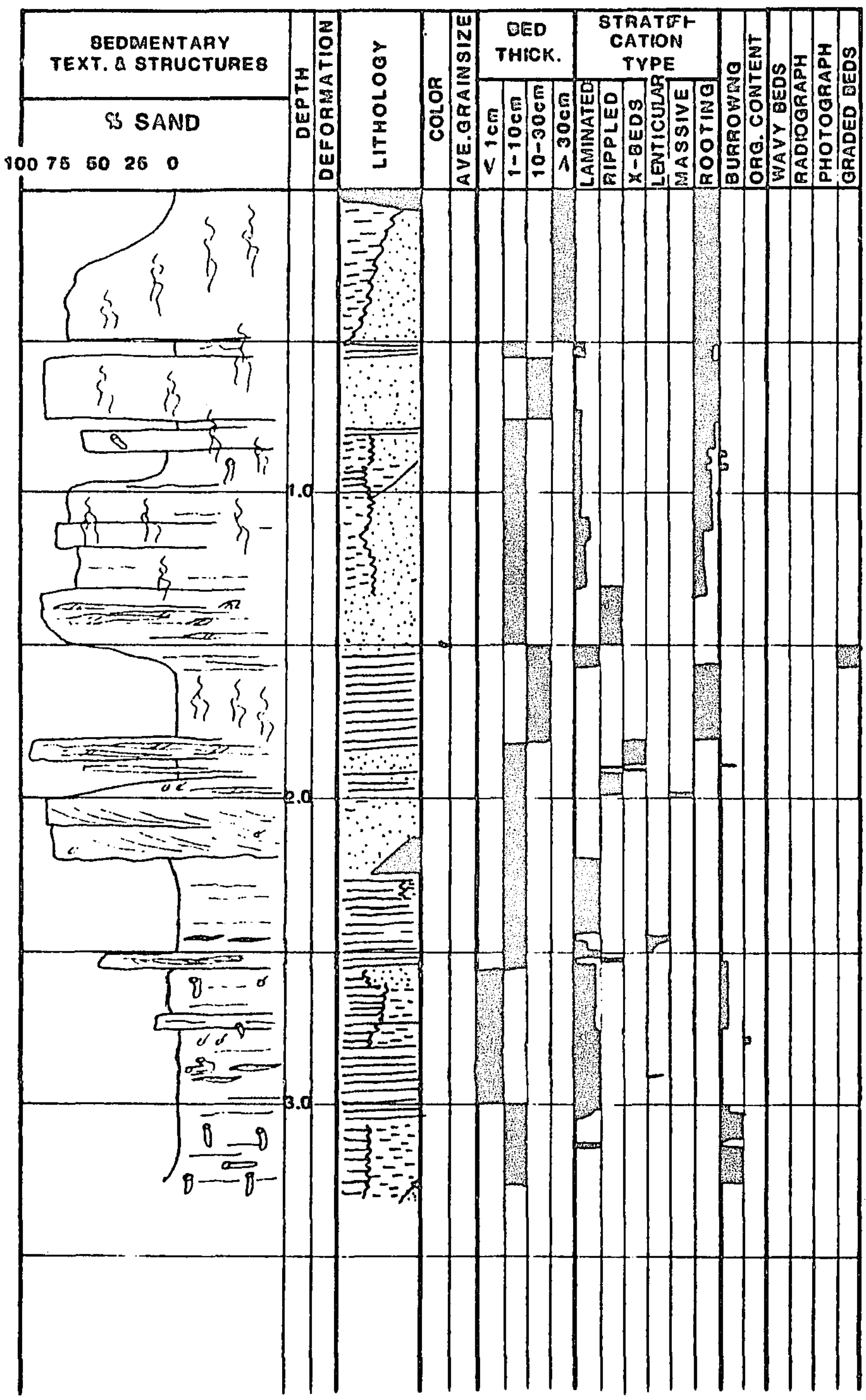
CORE NUMBER FP-71 CORE DEPTH (M) 2.36

LOCATION LAKE FAUSSE POINTE



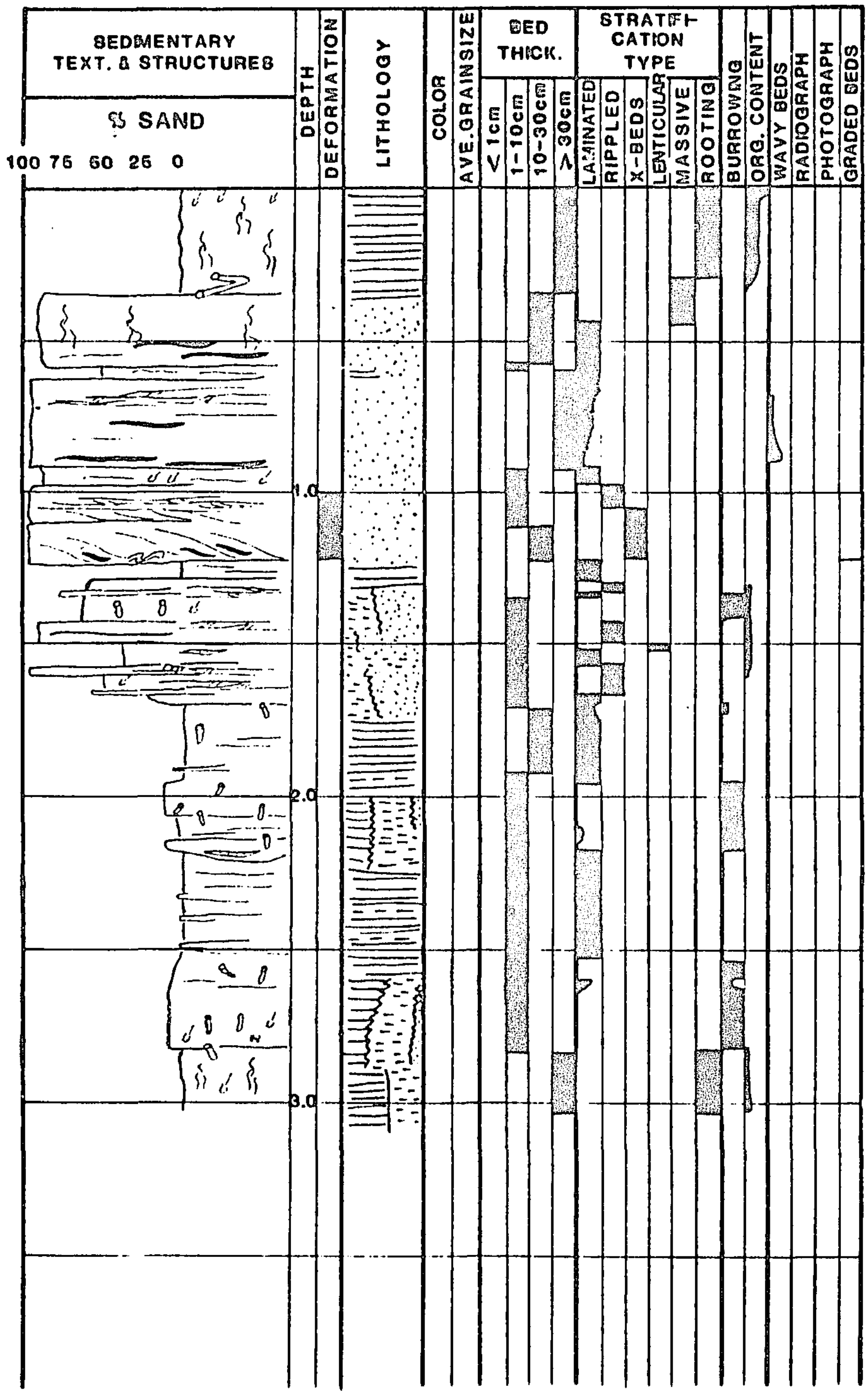
CORE NUMBER FP-72 CORE DEPTH (M) 3.25

LOCATION LAKE FAUSSE POINTE



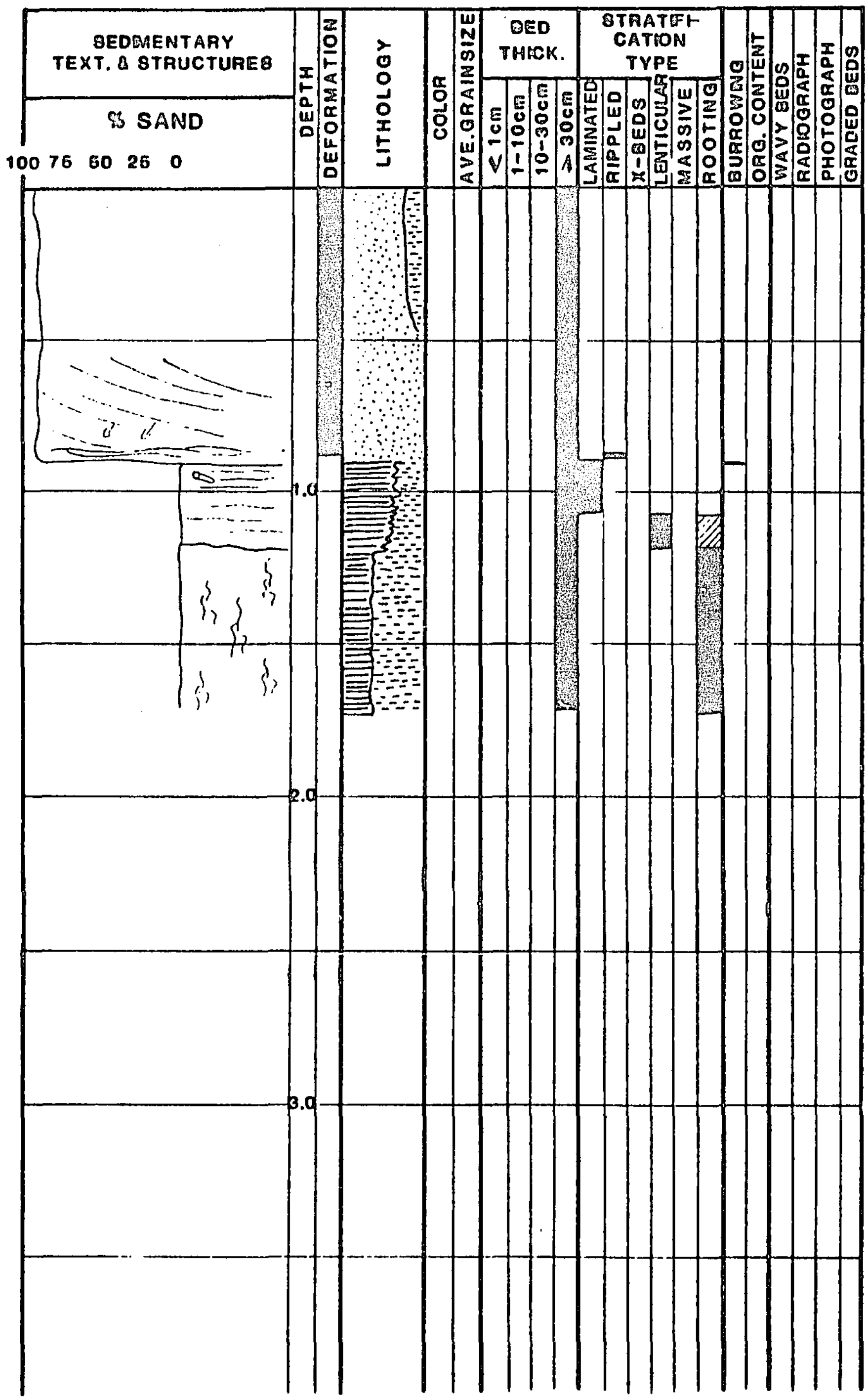
CORE NUMBER FP-73 CORE DEPTH (M) 3.03

LOCATION LAKE FAUSSE POINTE



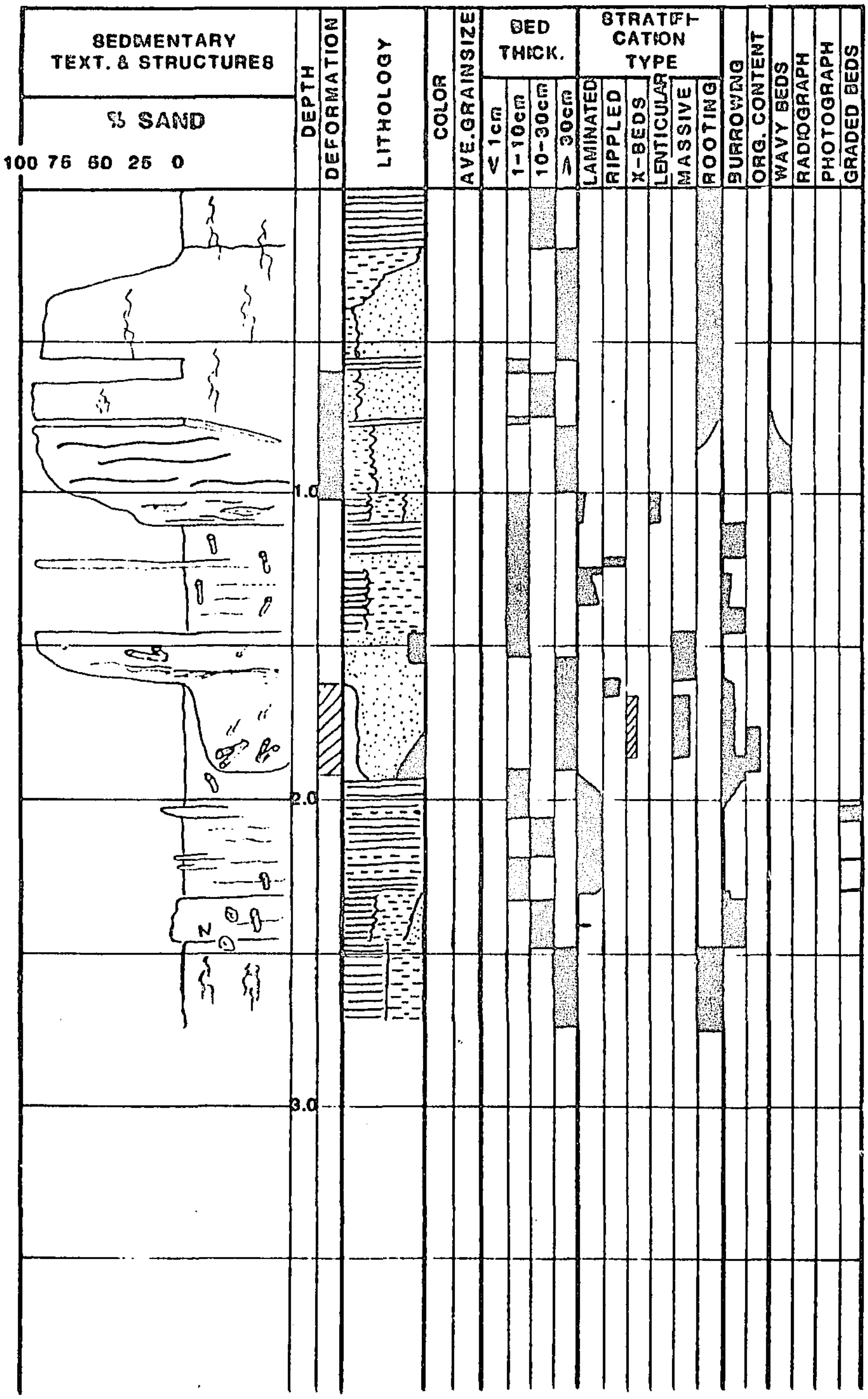
CORE NUMBER FP-74 CORE DEPTH (M) 1.71

LOCATION LAKE FAUSSE POINTE



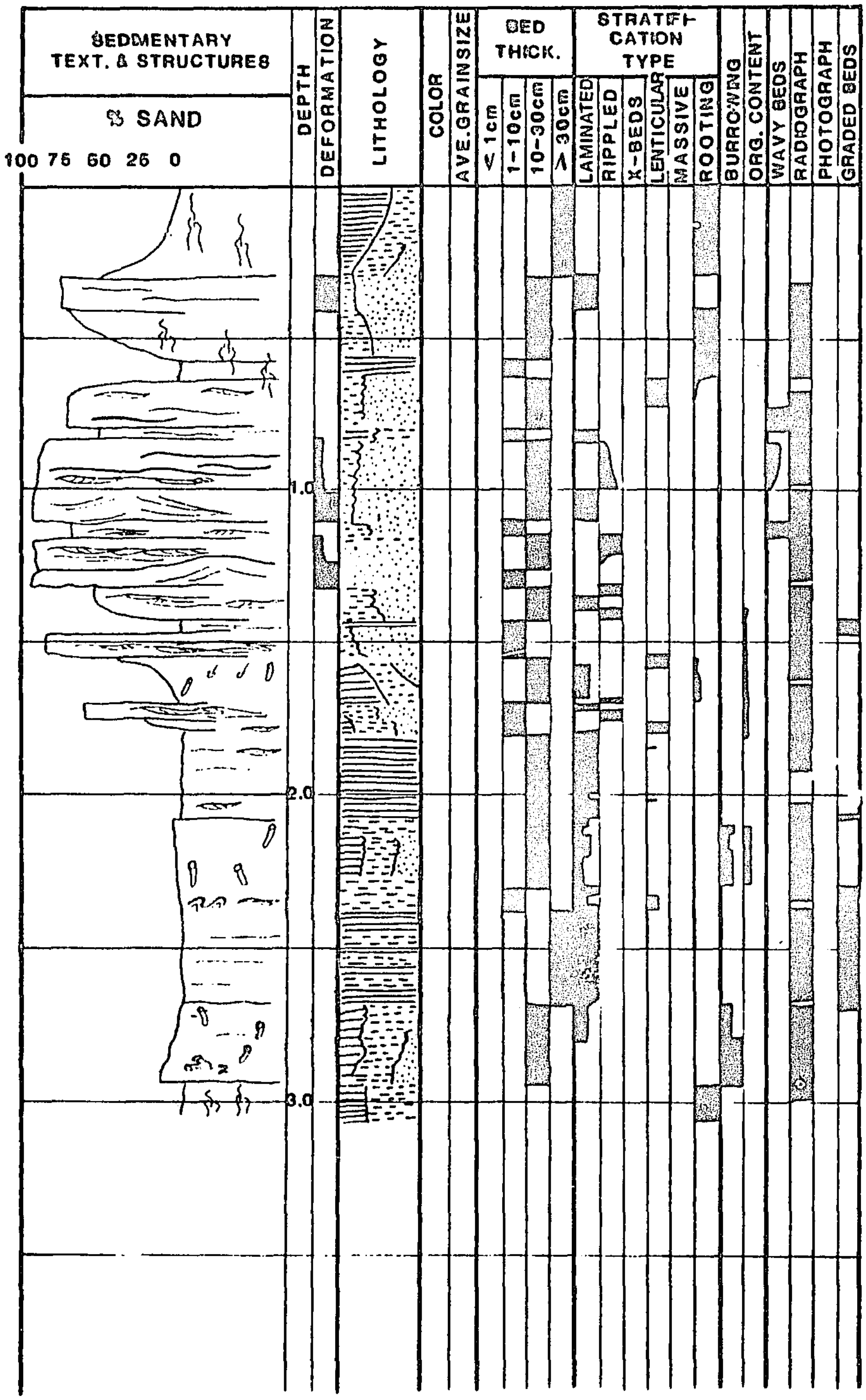
CORE NUMBER FP-75 CORE DEPTH (M) 2.74

LOCATION LAKE FAUSSE POINTE



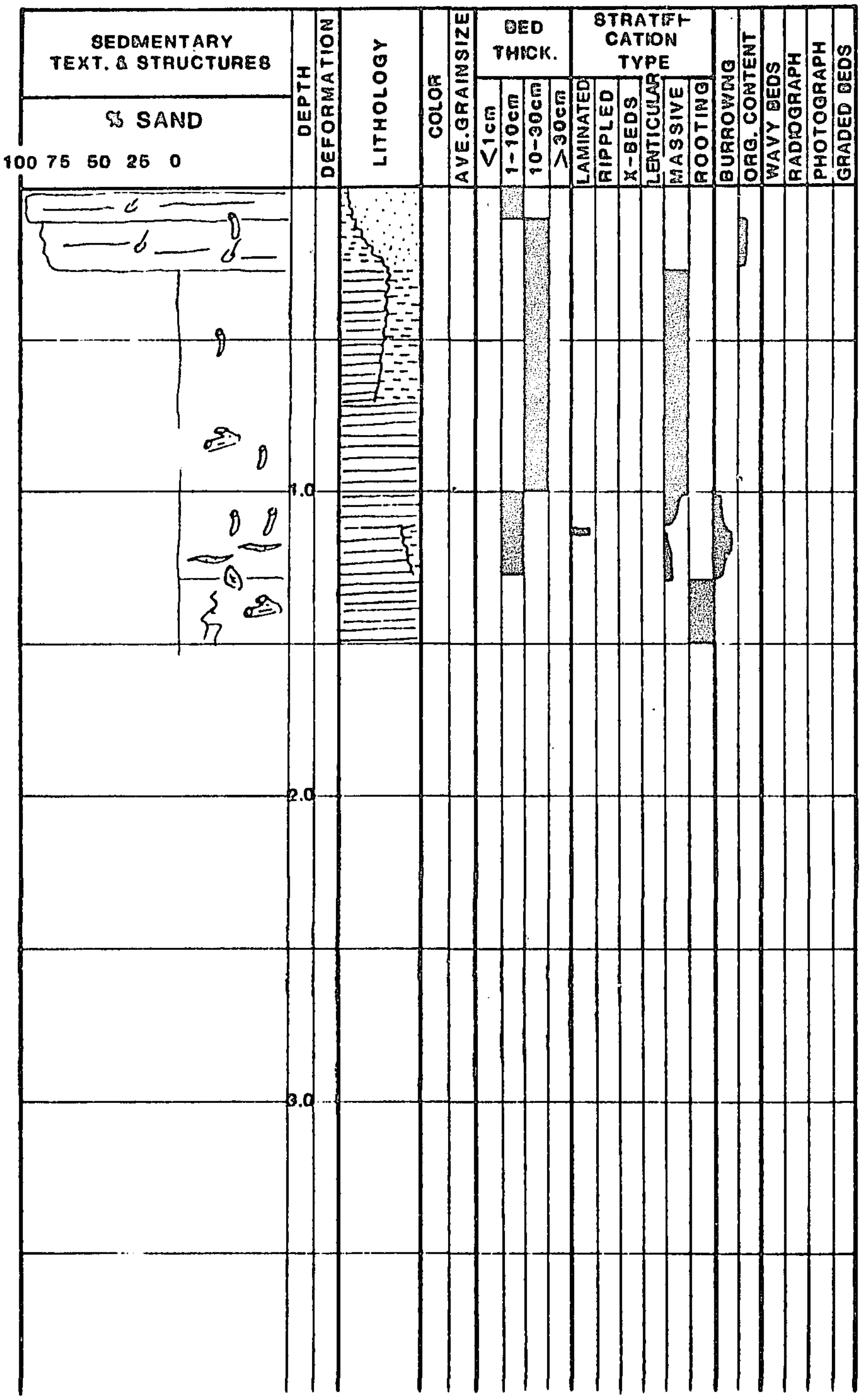
CORE NUMBER FP-76 CORE DEPTH (M) 3.10

LOCATION LAKE FAUSSE POINTE



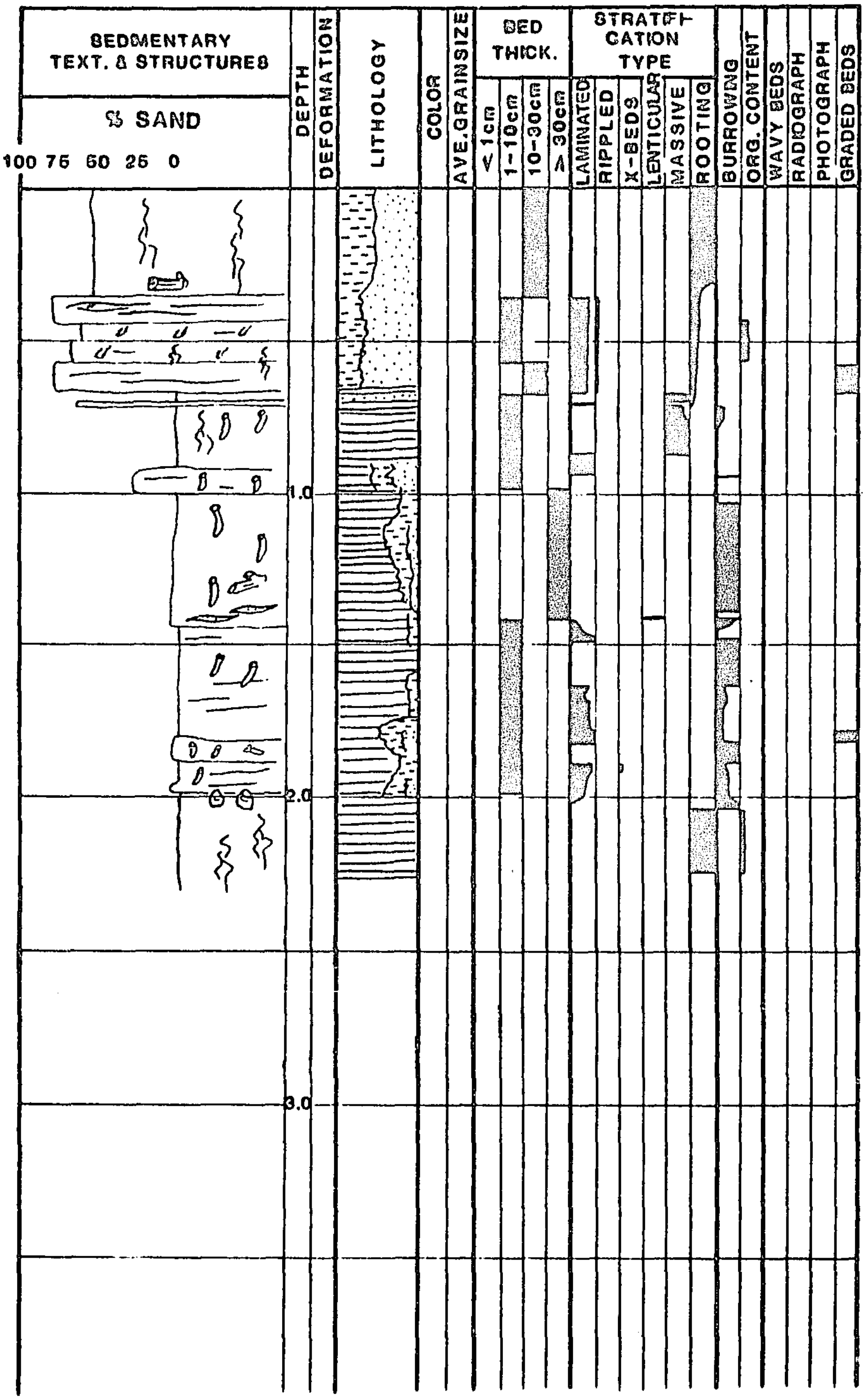
CORE NUMBER FP-77 CORE DEPTH (M) 1.50

LOCATION LAKE FAUSSE POINTE



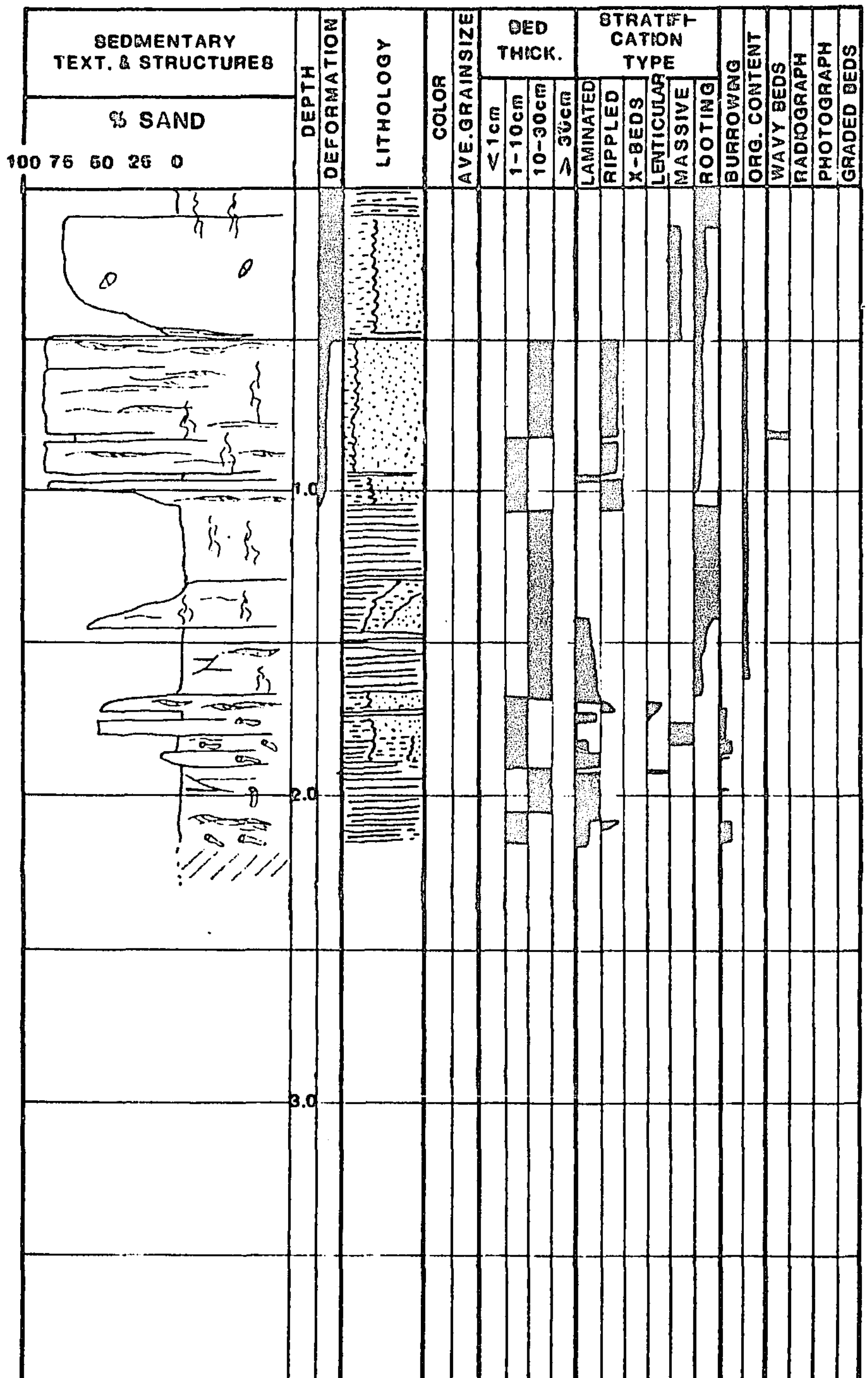
CORE NUMBER FP-78 CORE DEPTH (M) 2.25

LOCATION LAKE FAUSSE POINTE



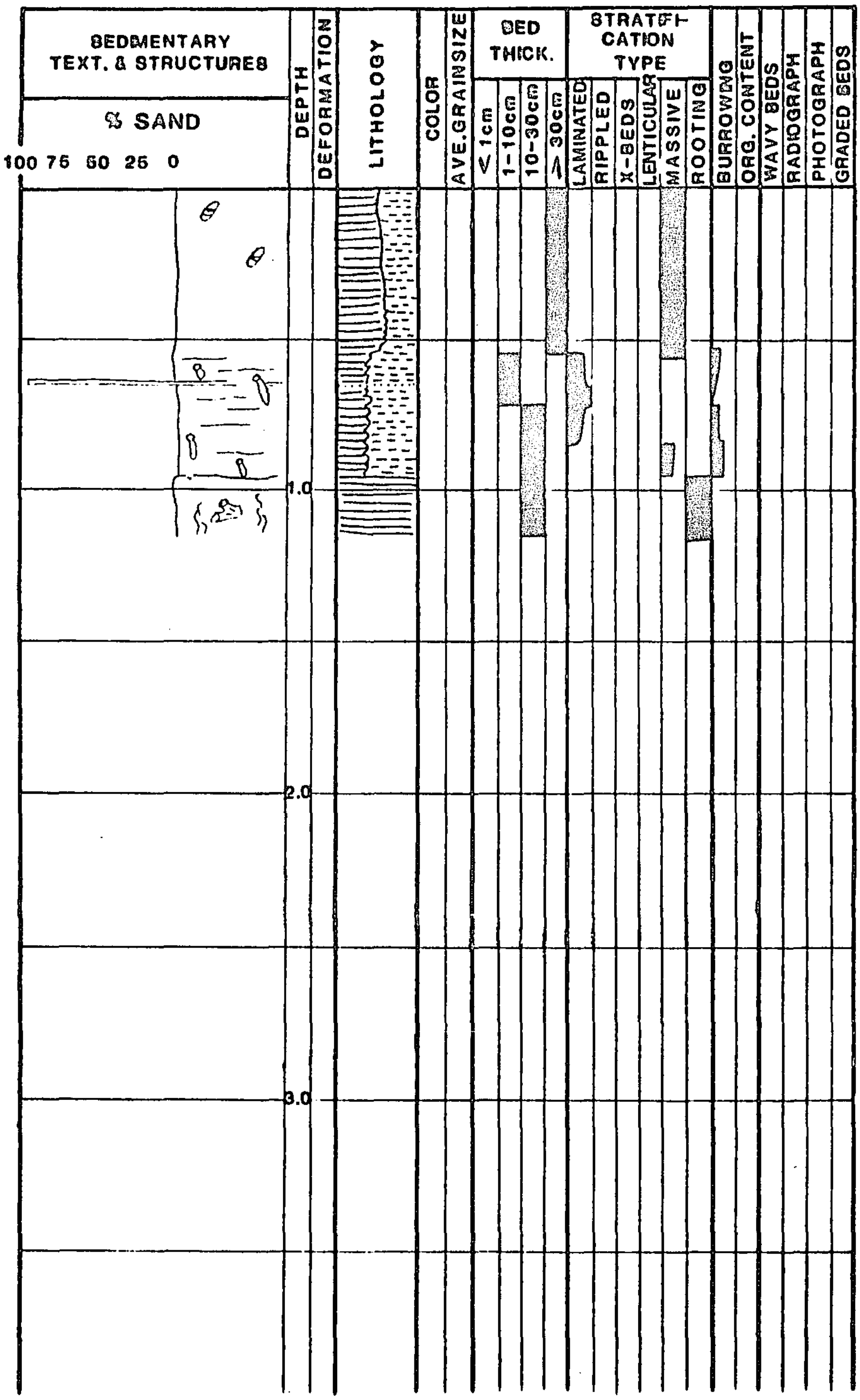
CORE NUMBER FP-79 CORE DEPTH (M) 2.15

LOCATION LAKE FAUSSE POINTE



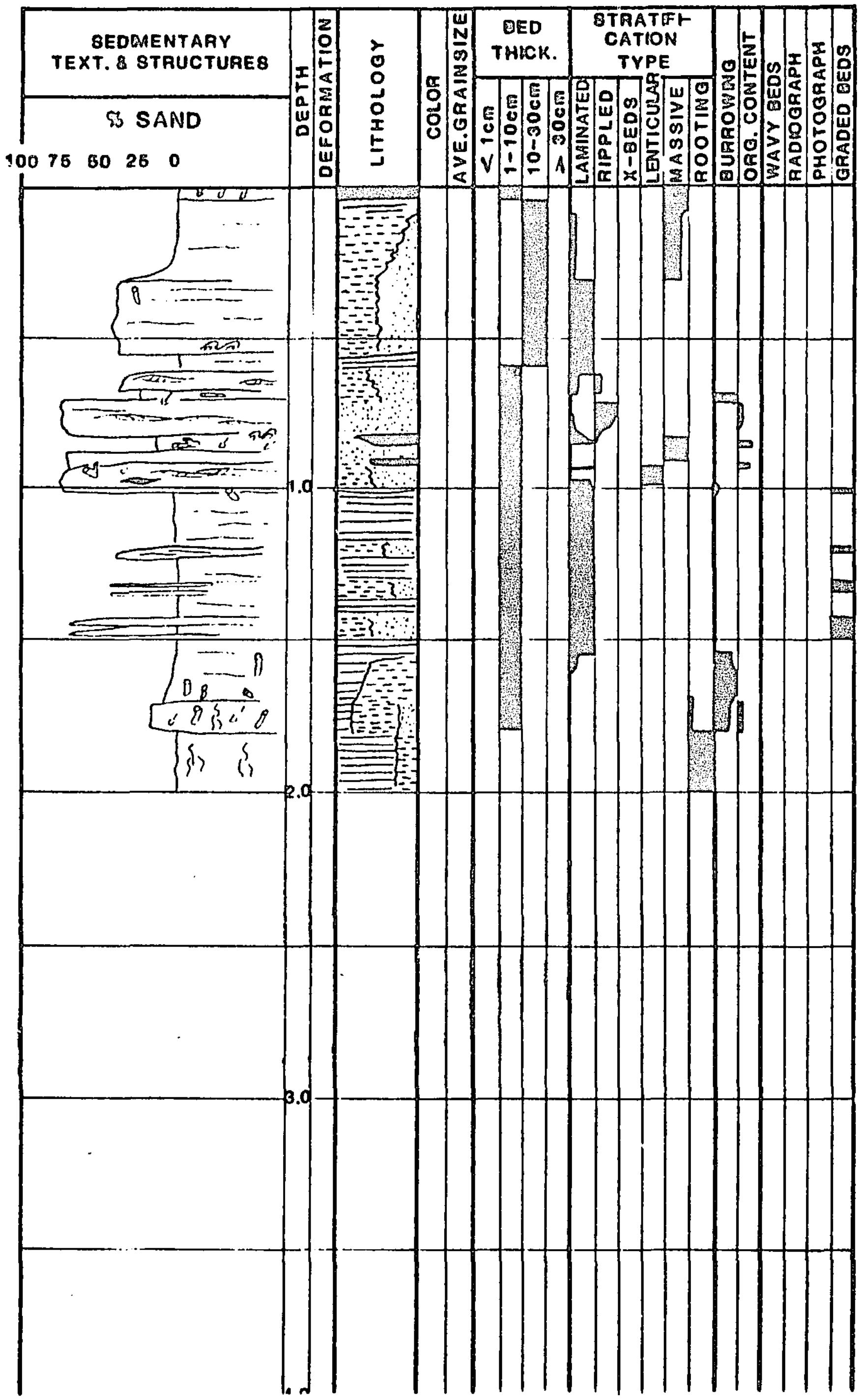
CORE NUMBER FP-80 CORE DEPTH (M) 1.16

LOCATION LAKE FAUSSE POINTE



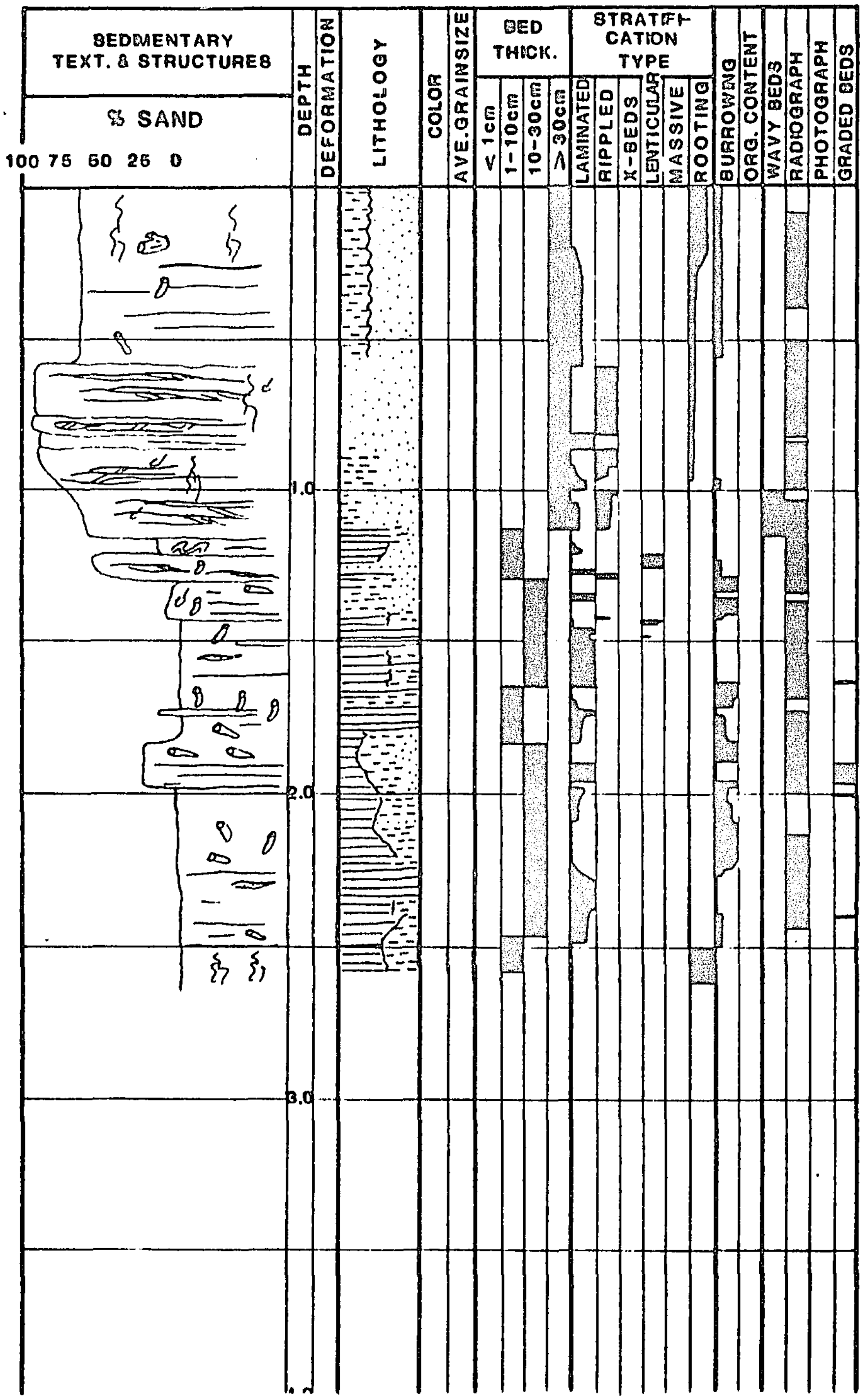
CORE NUMBER FP-81 CORE DEPTH (M) 1.98

LOCATION LAKE FAUSSE POINTE



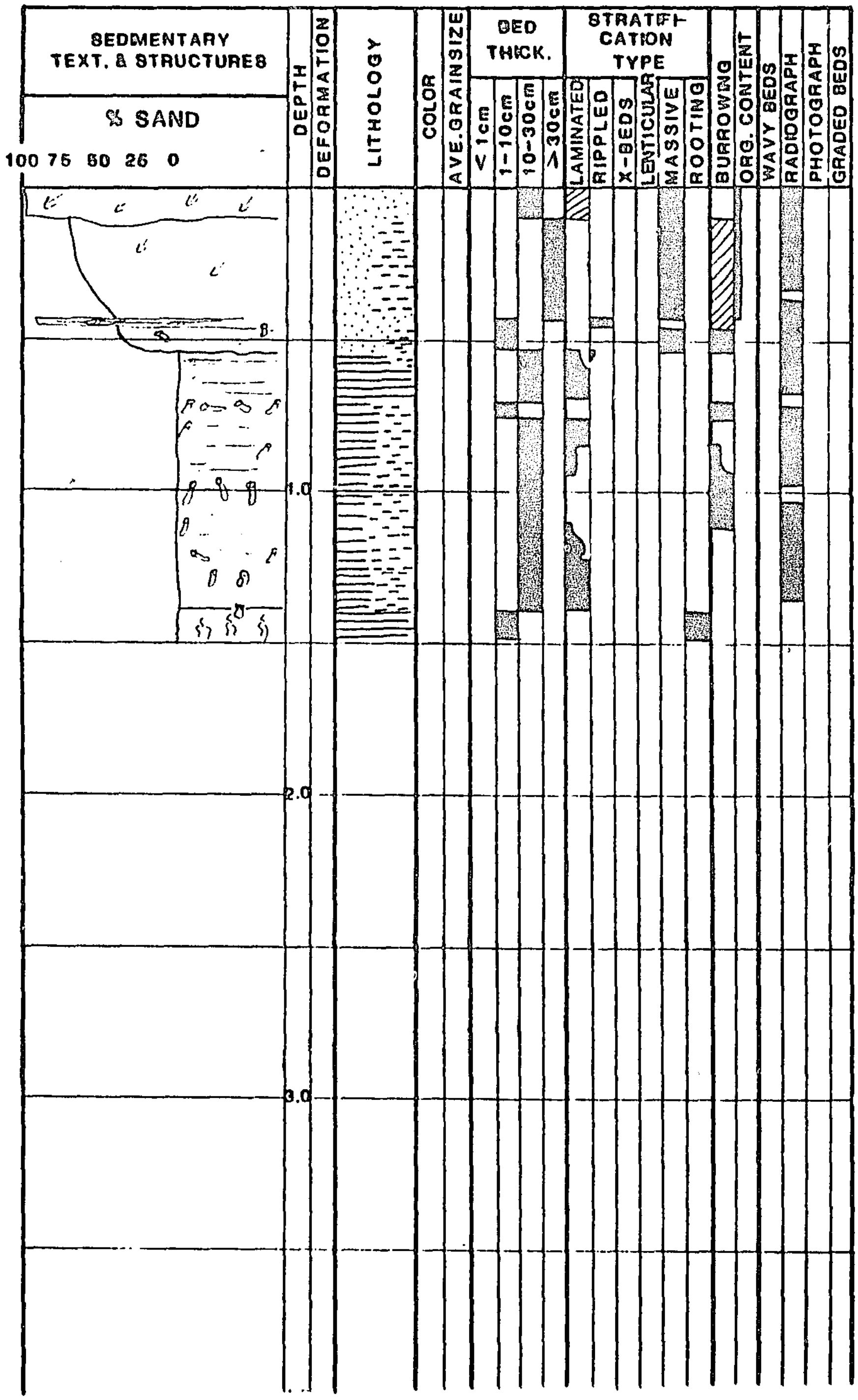
CORE NUMBER FP-82 CORE DEPTH (M) 2.57

LOCATION LAKE FAUSSE POINTE



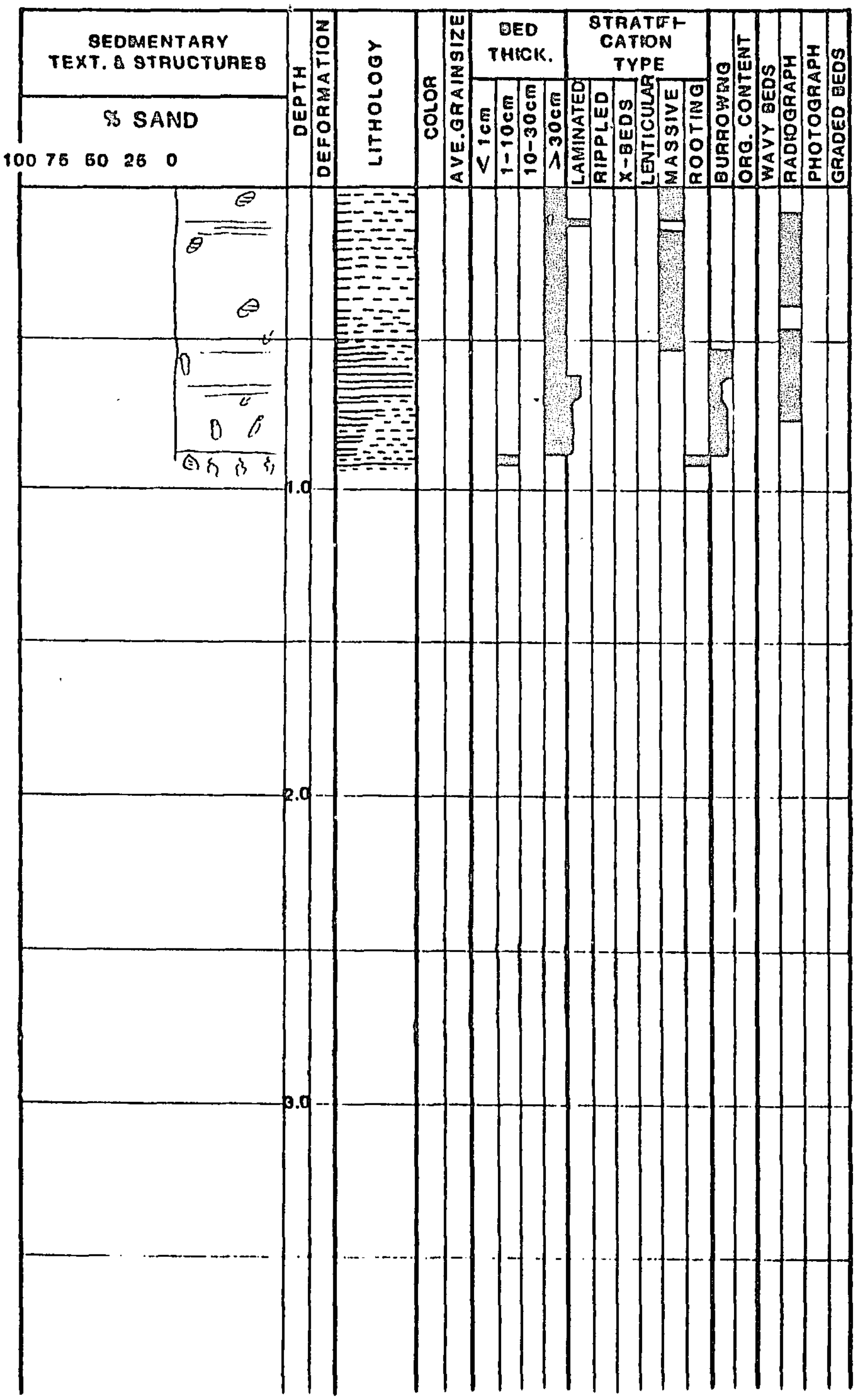
CORE NUMBER FP-83 CORE DEPTH (M) 1.47

LOCATION LAKE FAUSSE POINTE



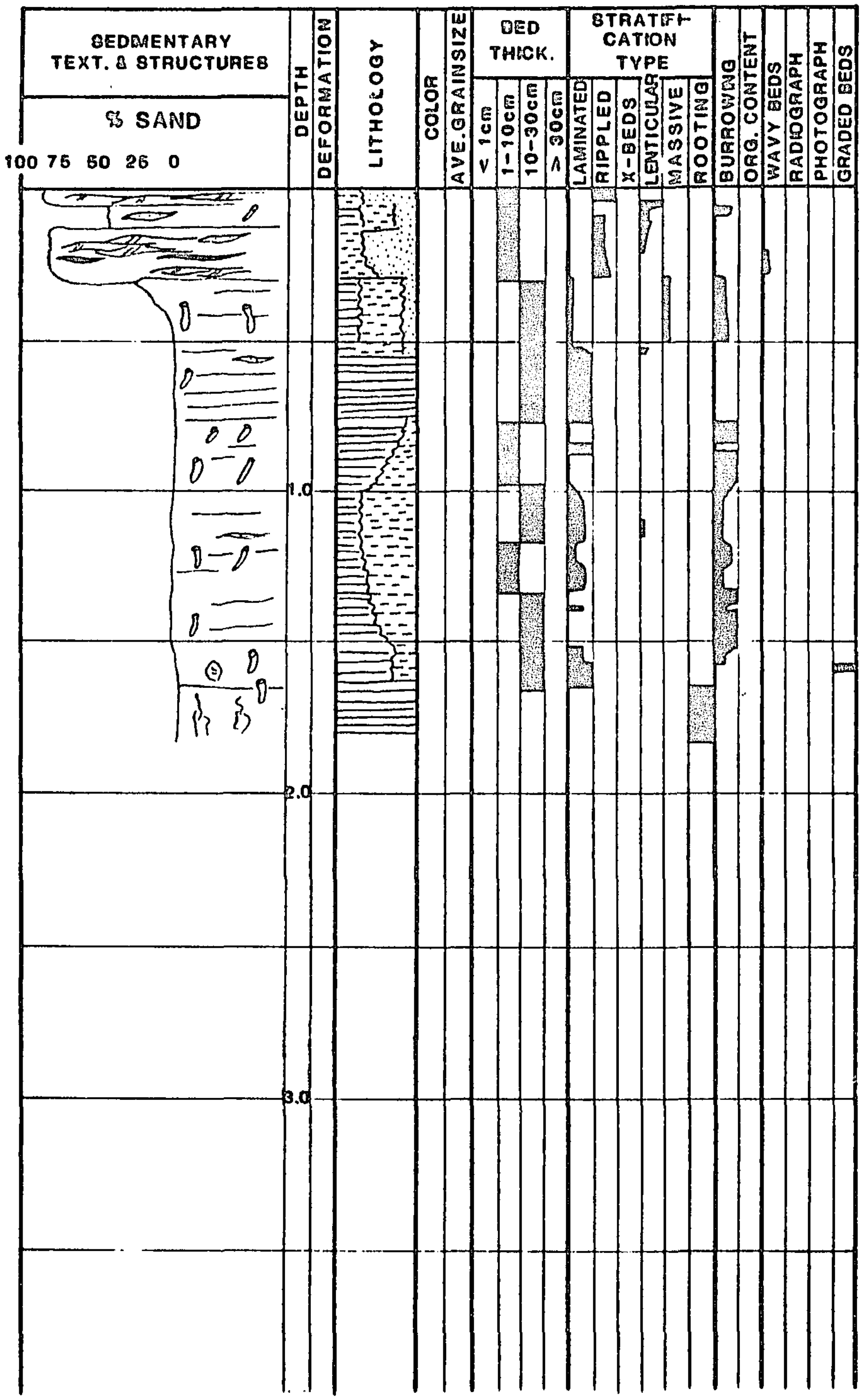
CORE NUMBER FP-84 CORE DEPTH (M) 0.92

LOCATION LAKE FAUSSE POINTE



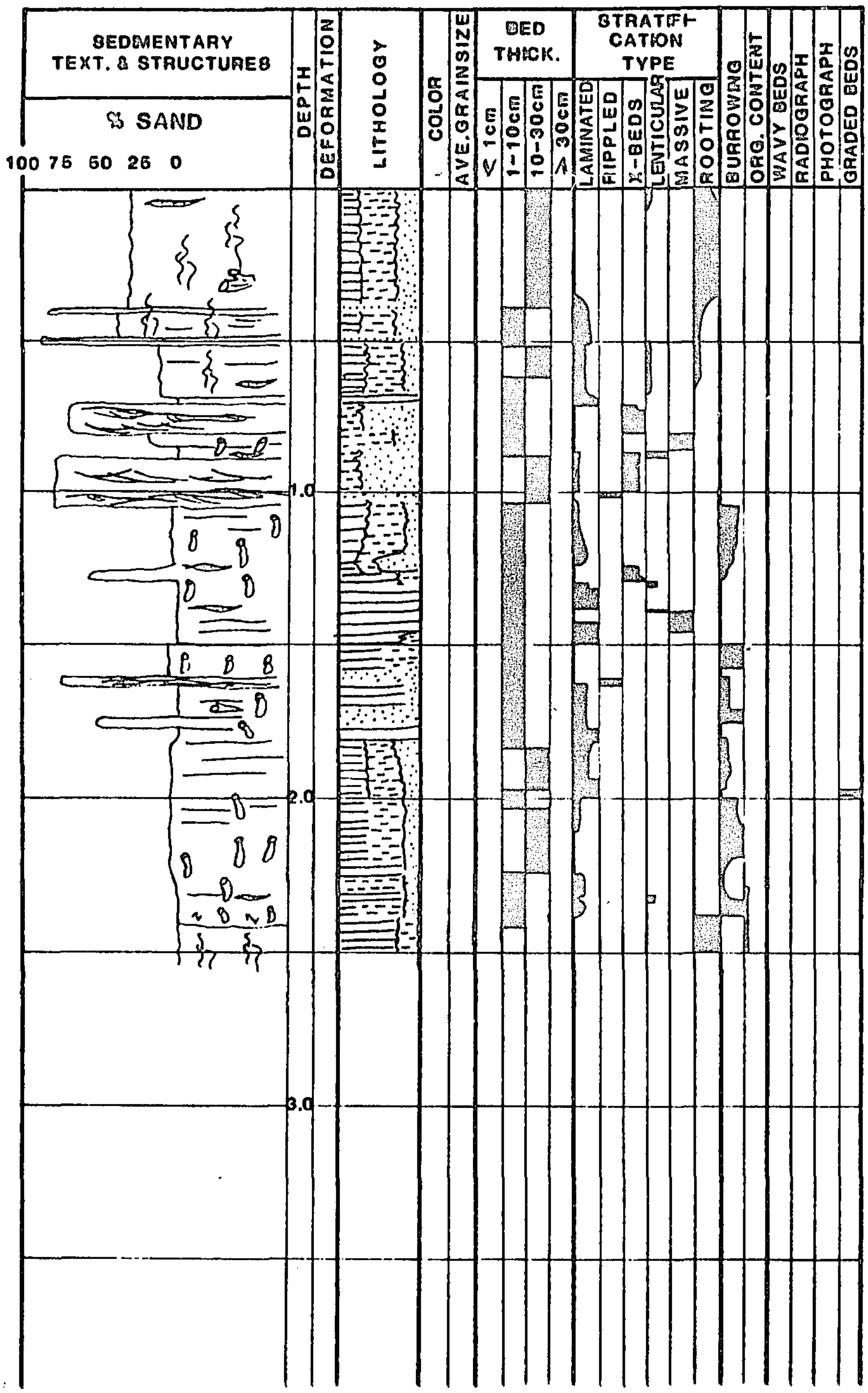
CORE NUMBER FP-85 CORE DEPTH (M) 1.79

LOCATION LAKE FAUSSE POINTE



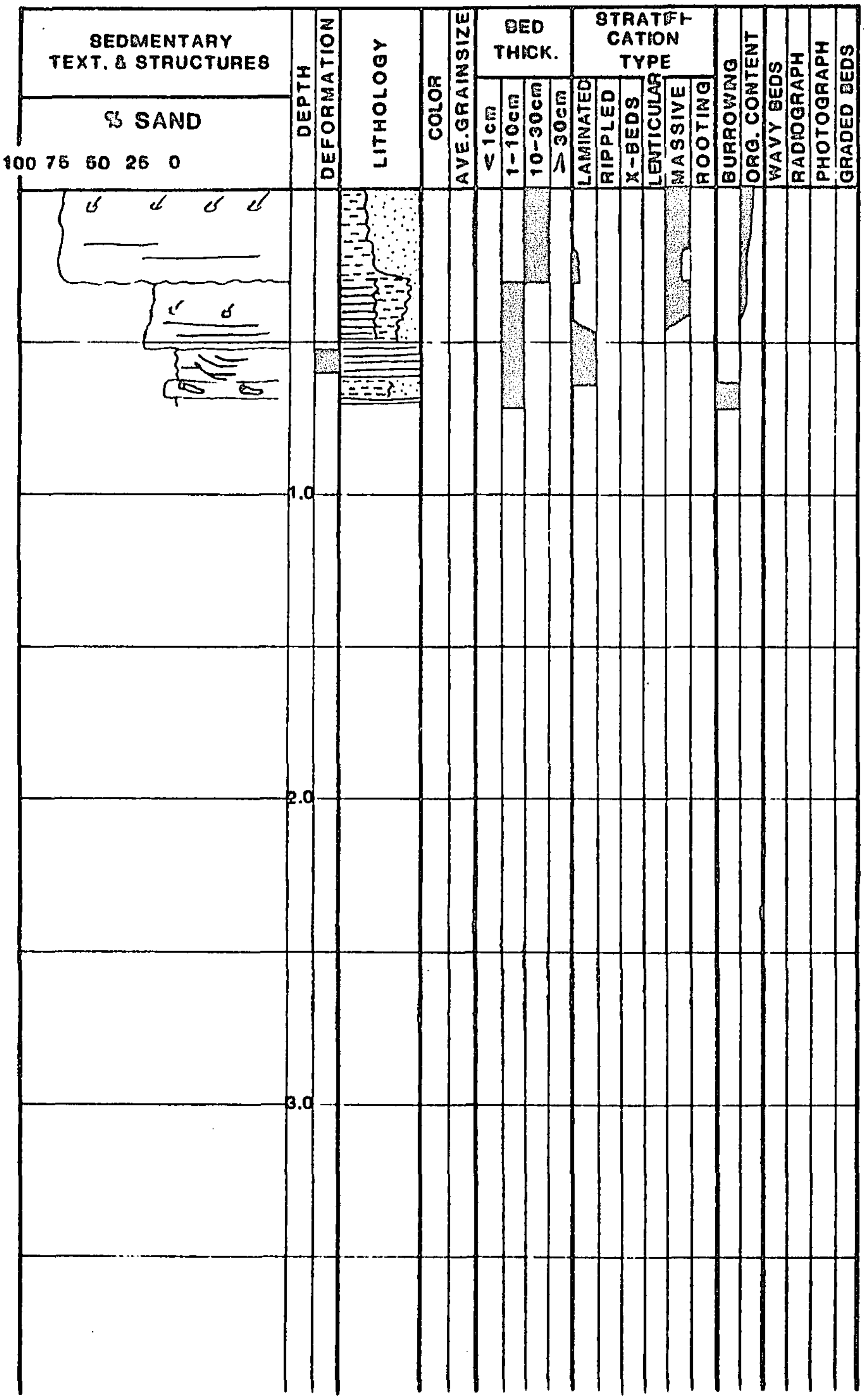
CORE NUMBER FP-86 CORE DEPTH (M) 2.50

LOCATION LAKE FAUSSE POINTE



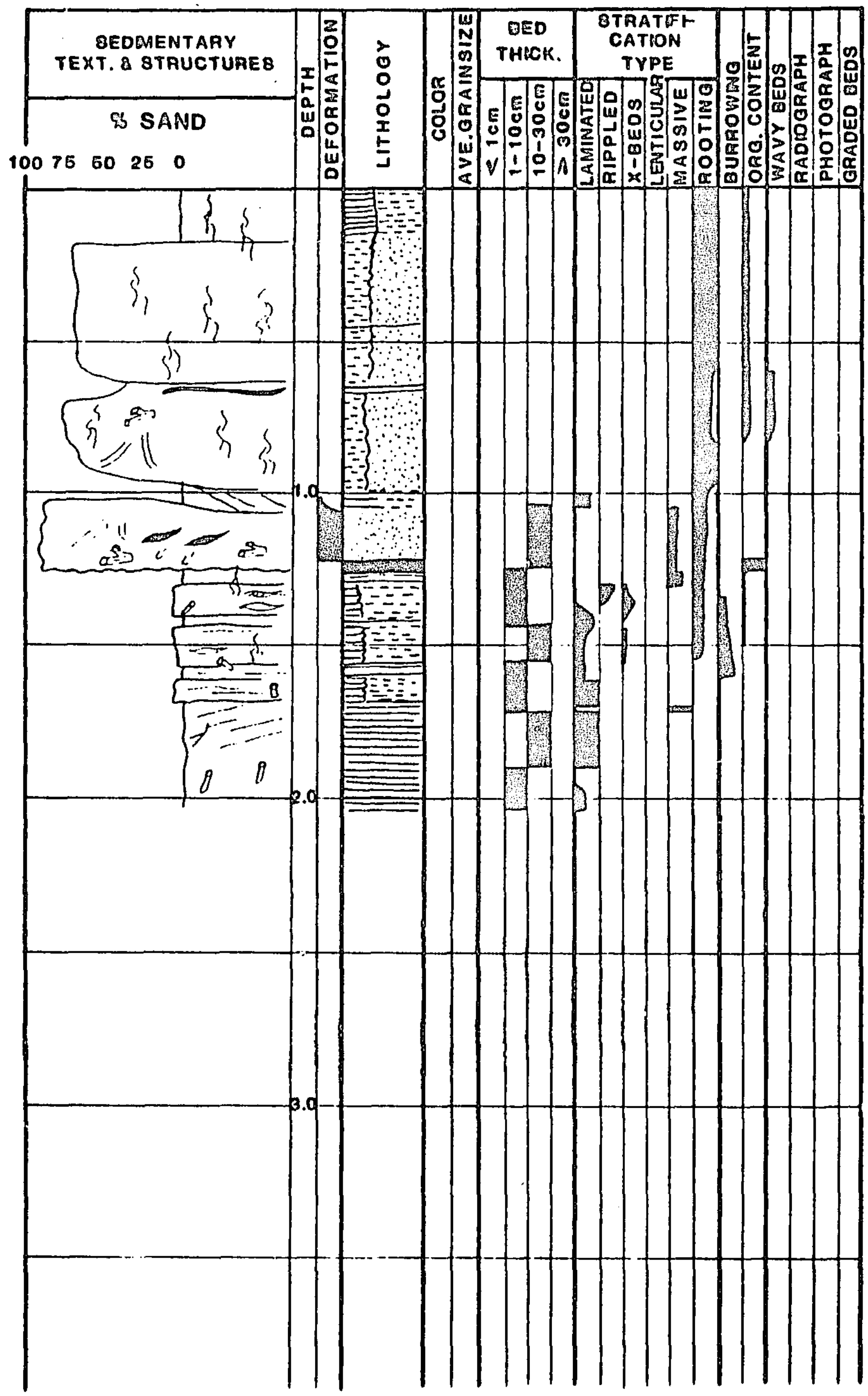
CORE NUMBER FP-87 CORE DEPTH (M) 0.68

LOCATION LAKE FAUSSE POINTE



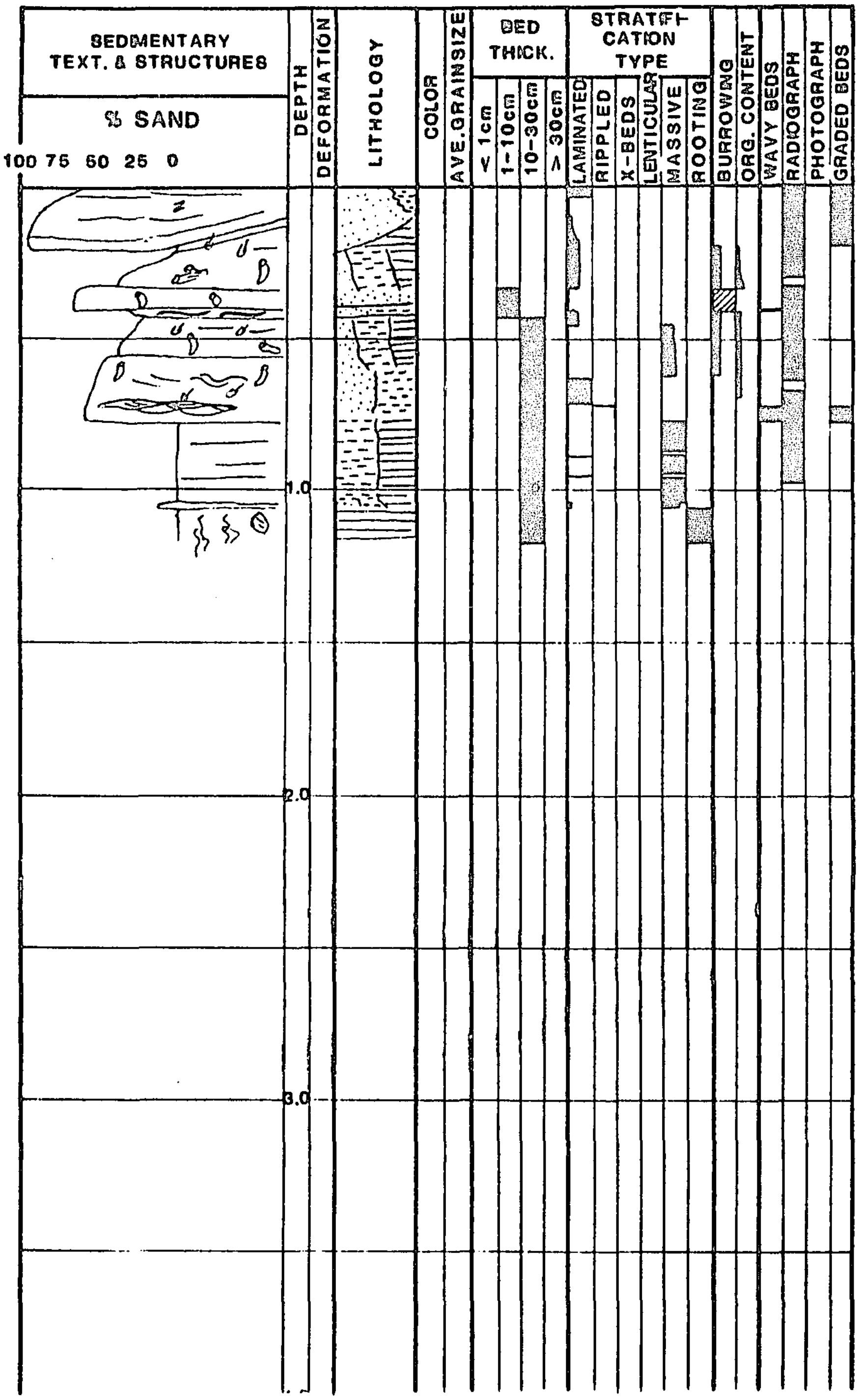
CORE NUMBER *FP-88* CORE DEPTH (M) *2.04*

LOCATION LAKE FAUSSE POINTE



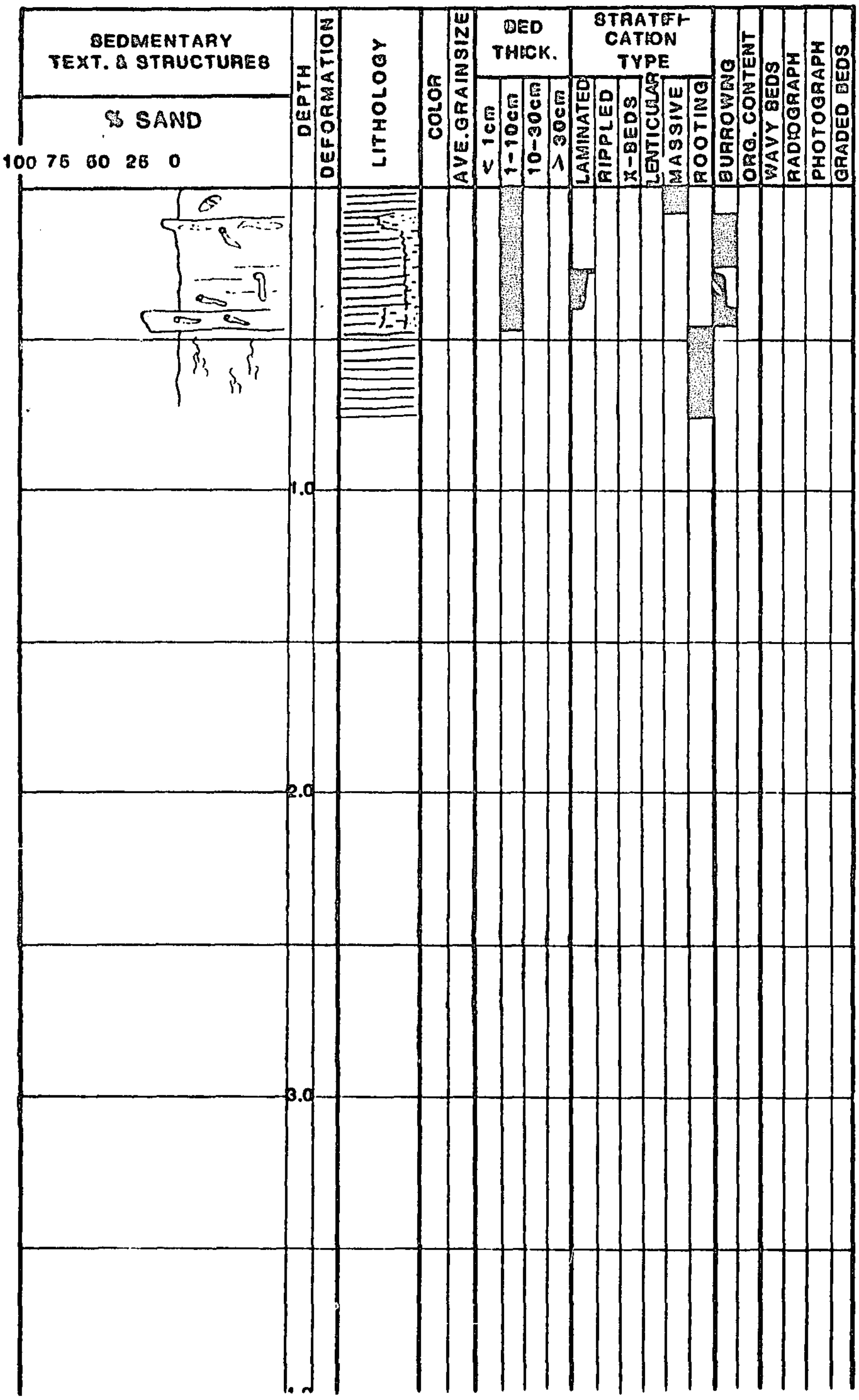
CORE NUMBER FP-80 CORE DEPTH (M) 1.15

LOCATION LAKE FAUSSE POINTE



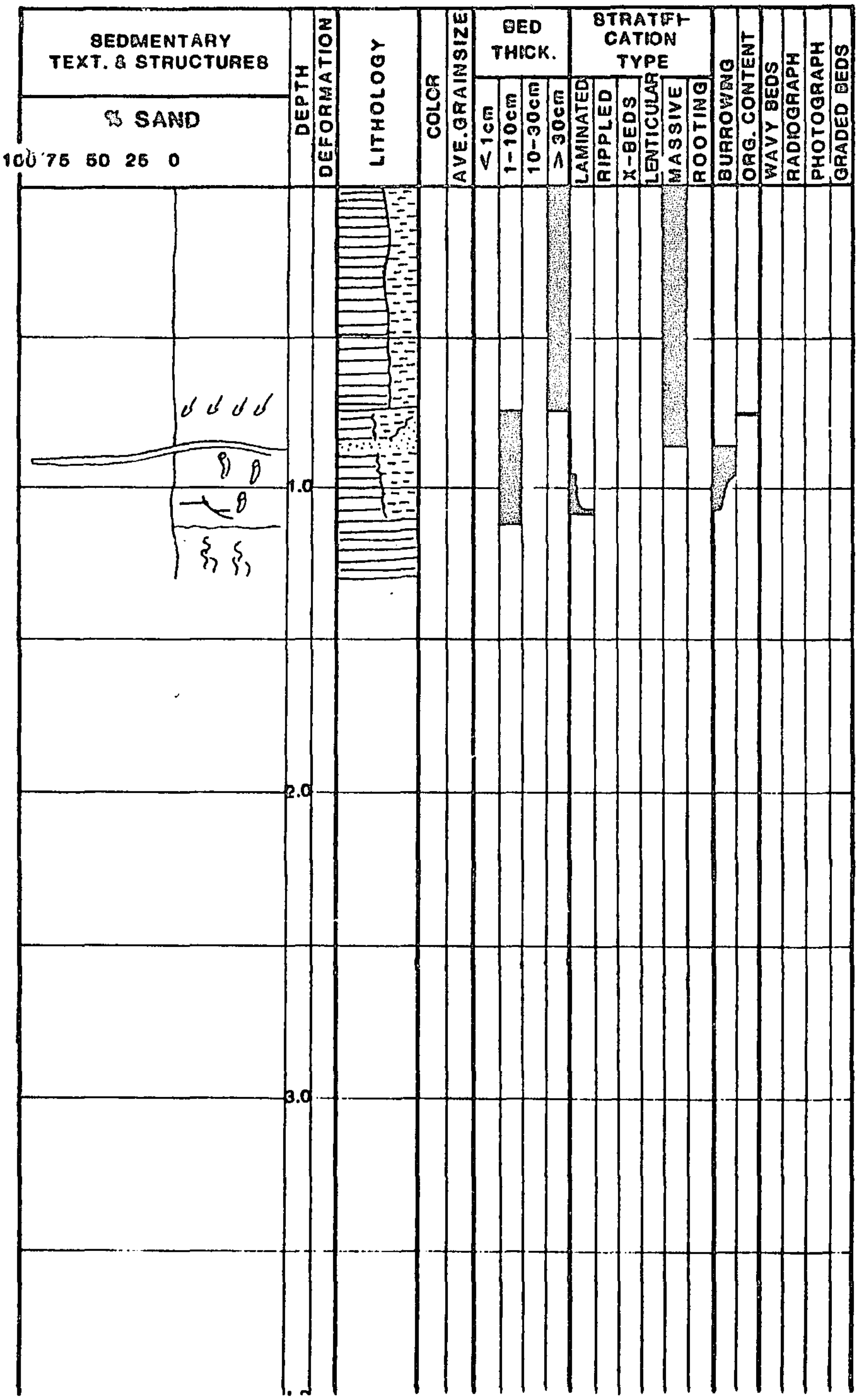
CORE NUMBER FP-90 CORE DEPTH (M) 0.75

LOCATION LAKE FAUSSE POINTE



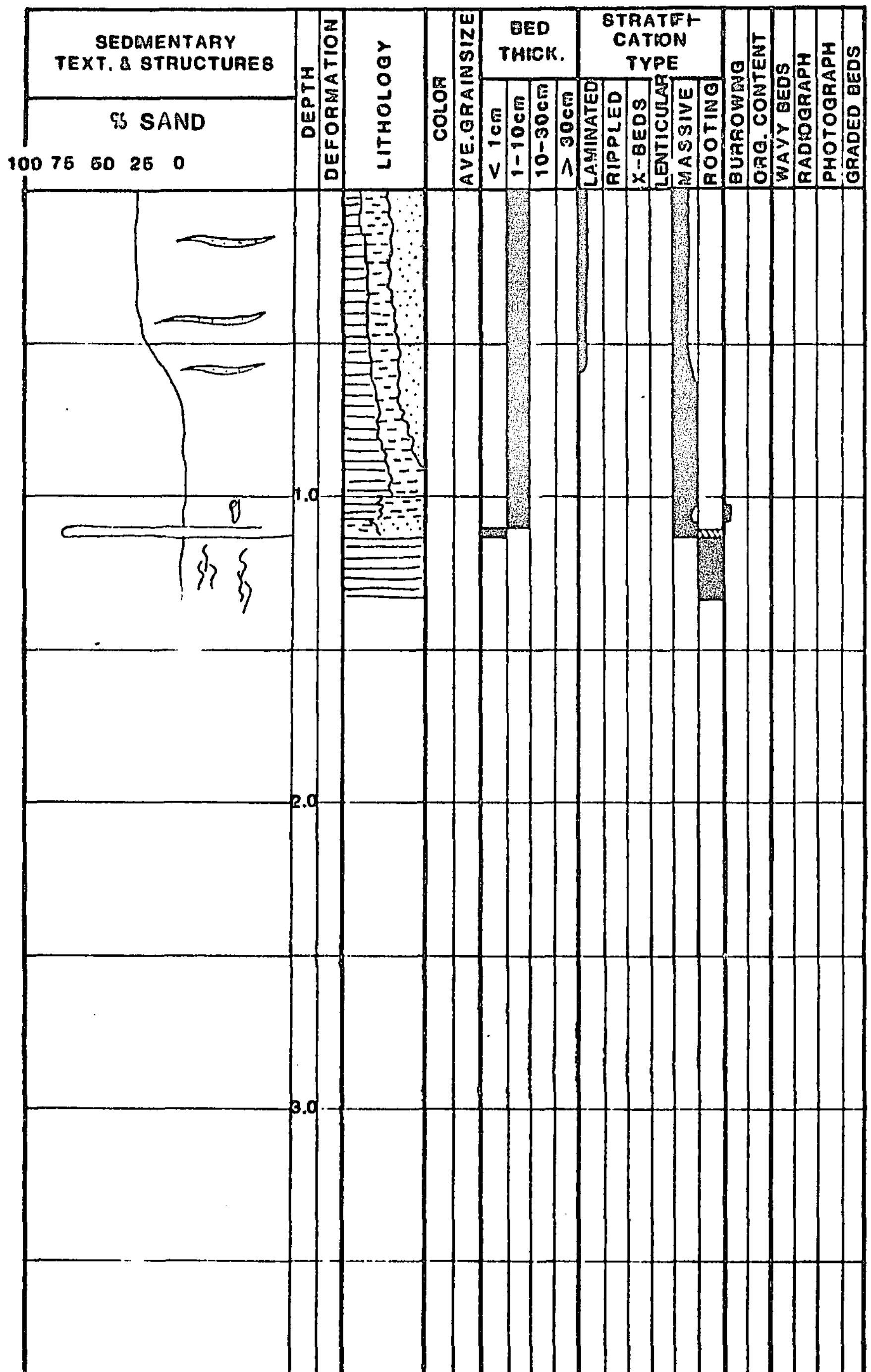
CORE NUMBER FP-91 CORE DEPTH (M) 1.28

LOCATION LAKE FAUSSE POINTE



CORE NUMBER FP-92 CORE DEPTH (M) 1.31

LOCATION LAKE FAUSSE POINTE



VITA

Robert S. Tye was born on 6 February, 1956 and grew up on James Island, just outside of Charleston, South Carolina. Following his high school graduation, Bo entered the College of Charleston where he received his B.S. degree in Geology. His earlier interest in, and enjoyment of the beaches and marshes in South Carolina had been heightened by his geologic training, and therefore, he chose to pursue a Master's of Science degree under Miles O. Hayes at the University of South Carolina.

From 1981 to 1983, Bo worked as a reservoir geologist at the Cities Service Technology Center in Tulsa, Oklahoma where he met Ellen Rose Naiman. They were married in 1983. Following their early dismissal from Cities Service Company due to the depressed oil economy, Ellen and Bo moved to Baton Rouge, Louisiana so that Bo could enter the Ph.D. program at Louisiana State University. Presently, they are anxiously awaiting the eminent arrival of a son or daughter, and hope that Bo can acquire permanent employment.

DOCTORAL EXAMINATION AND DISSERTATION REPORT

Candidate: Robert S. Tye

Major Field: Marine Sciences

Title of Dissertation: NON-MARINE ATCHAFALAYA DELTAS: PROCESSES AND PRODUCTS OF INTERDISTRIBUTARY BASIN ALLUVIATION, SOUTH-CENTRAL LOUISIANA

Approved:

Major Professor and Chairman

Dean of the Graduate School

EXAMINING COMMITTEE:

Date of Examination:

October 7, 1986